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Neglected Colonies.

PUBLIC attention has been largely devoted to British Colonies during the past two or three years, and especially within the last few months. Everyone of British blood must necessarily feel proud of the manner in which distant states have freely taken upon themselves part of the cares and burdens of an empire, and the hope is universally expressed that the mother country and her children may be drawn into still closer union than has existed in the past. With feelings and sentiments of the kind we have every sympathy, and it is owing to this fact that we take the opportunity of pointing out the neglect that is too often the fate of small colonies under the control of the Crown Agents in London. We do not know anything more antagonistic to development than bureaucracy, nor more soulless than government departmentalism. Yet some thirty or more of our small colonies are more or less in the clutches of such creations, and it is therefore difficult to see how they can be expected to grow into great and prosperous states like the self-governing colonies which justly occupy so prominent a position in the popular imagination. To illustrate our meaning more fully we will take one or two examples. The first relates to the territory known as British Central Africa: planters are there dependent upon natives as the only available means of transport, and great need exists for railway communication between Nyasa and the sea. A scheme has already been formulated for the construction of a railway line, but it appears that the Foreign Office and the Treasury have hitherto hindered its realisation. Such action, or perhaps inaction, is all the more incomprehensible for the reason that the opening up of the district in question would materially assist in the solution of the labour problem in South Africa. There are thousands of natives north of the Zambesi who would be available as workers in the mines if adequate railway communications were in existence.

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A much worse example of official inertia is afforded by continued procrastination in connection with railway enterprise in British Honduras. This unfortunate settlement is drooping yearly, and ruin begins to stare colonists in the face. For the purpose of helping to improve upon this lamentable state of things, a railway has been projected to run from Belize to the frontier of Guatemala, a distance of about 75 miles. All who understand the needs of the colony approve the scheme. The Governor, the legislature, the colonists, and even the Government of Guatemala, look upon it with favour. As proof of their practical interest in the venture, the last-named Government have volunteered to give facilities for the extension of the line into their own territory, and to grant land and privileges to make easier the task of the promoters. From the surveys already made it is clear that the construction of the line would present no engineering difficulties, and that the cost would be comparatively small. In fact, a well-known firm of British financiers has offered to build the line in return for a payment of £100,000 and a grant of 200,000 acres of land, the value of which is about £40,000. This offer is perfectly acceptable to the colony, but not to the Crown Agents in Downing Street. These tape-bound officials appear to have made a calculation of their own, and, believing

the railway would cost five times the price asked by experienced business men, they refuse to sanction its construction. This affectation of tender-hearted solicitude for the pockets of a contracting firm is quite a new feature in departmental government. No sane person is likely to believe in it, or in the preposterous estimate of cost, cast in an obsolete official mould. As matters stand, business prospects in the colony are steadily growing worse, and it is difficult to see what can be done to avert the consequences of neglect from this unhappy portion of the Empire.

Turning now to another phase of the question, we find that the mercantile and moneyed classes in Great Britain have not yet learned to appreciate the advantages to be derived from judicious investments in some of the smaller colonies. The result of such ignorance is sometimes that the colonies suffer, and at other times that foreigners step in to make money and to obtain a permanent hold upon British markets. With the object of showing that this is no imaginary position, we will consider the case of British Guiana. This colony is endowed with undeveloped mineral wealth, probably of greater magnitude than that of British South Africa. In former times it was possible for an owner of land, in some parts of the colony, to obtain 1,500 ounces of gold per month by the crudest operations conducted in the beds of creeks draining the hills, but at the present time even the richer parts of the country no longer offer large profits to unskilled workers using wasteful methods. Nevertheless, the gold-bearing deposit of the colony has barely been scratched, and the only things now lacking are capital and initiative to place British Guiana in the foremost rank of gold-producing British Possessions. The financial position of the gold mining industry is that a period of general depression has made credit difficult to those who would otherwise be able to show a good production, while a large amount of the available local capital has been attracted by the more alluring diamond fields. People at home know little or nothing of the colony, believing it to be merely a sugar-cane growing country; but the fact is, that out of 109,000 square miles only 150 square miles are under cultivation, and the greater part of the interior is practically unexplored.

While the British nation is sleepily neglecting this colony, Americans and Germans are wide-awake and active. American capital is already coming in, and an exploration of the interior is spoken of as probable. A German syndicate has just completed the erection of a large hydraulic plant for gold production on the modern system. Negociations are also proceeding with a Dutch company having a capital of £250,000 to take over and work some of the gold claims, and it is said on good authority that the diamond industry is practically in the hands of American capitalists.

It would be easy to give other instances of apathy and ignorance as to the immense natural resources of our colonial possessions, but we have said enough to show clearly the danger that exists. As the future strength and prosperity of the empire will depend largely upon the development of its individual states, and the realisation of co-operative sympathy between all of them, we trust that "neglected colonies" may soon be unknown.

The Education of Engineers.

A DISTINGUISHING feature of the true engineer is that he remains a student as long as he lives. It may be, and probably is the case, that a similar willingness to learn is felt by members of other professions, but the character of the work falling to the lot of the engineer is such that the necessity of learning is impressed upon him year by year, and even day by day. As Professor John Perry put the case in the course of his recent address to the Engineering Section of the British Association: "The engineer

must study Nature in all her exasperating complexity. He must have all the knowledge of the scientific man, and ever so much more. He uses the methods of the scientific man, and adds to them methods of his own." Accepting this proposition as a basis, it is easy to see that mere school or college training cannot do more than furnish the tools for engineering work, and explain the manner in which they may be used. A certain manual dexterity may also be imparted, but no worthy work can be accomplished unless the hands are guided by a brain inspired by the true spirit of engineering. We quite agree with Professor Perry in thinking that long years of wearisome study in an institution such as a German gymnasium will do less for a man than a few months of personal contact with those who teach him to observe and to think for himself. In one case the student may be merely equipped with knowledge which he does not know how to apply, and in the other he may be said to have fairly commenced that higher education which lasts through life.

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Of course, every boy who aspires to become an engineer must have some preliminary education before entering a technical college, and it is very important that it should be of the right kind. Even at the present time things are taught that might be left untaught, and things are not taught that ought to be taught. Hence, boys are turned out with an excessive knowledge of Latin, and a very deficient acquaintance with their own language; mathematics are presented in such a way that the average pupil cannot understand Euclid, and learns to hate algebra for the rest of his life. We fully believe our school system is capable of improvement, but it is impossible to agree with Professor Perry when he says that it ought to be "scrapped." Everyone knows Professor Perry as an earnest reformer, with intensely practical ideas, who is doing admirable educational work. But when he lets himself go at a semi-holiday function, such as the Belfast meeting, he is apt to say things that must not be taken too literally. Established institutions cannot be rubbed out like sums on a schoolboy's slate, so that a fresh start can be made. They must rather be nourished, pruned, and trained like trees, so that they may continue to bring forth good fruit, and it is satisfactory to think that this is really being done at the present time. As to science schools and technical colleges, every one who will, may observe that such aids to technical education are many, and that they are rapidly increasing in number. Experimental science is being introduced into public schools and universities, and although the essentially practical methods of the Science and Art Department are not yet general, their value is becoming more and more recognised every year. Competent teachers and lecturers are still difficult to obtain, partly because the pay offered is inadequate, and partly also for the reason that professional teachers cannot always be professional engineers at the same time. "Professor's engineering" has long been a by-word among practical men, and so it will remain until professors of purely engineering subjects are men able to keep themselves thoroughly in touch with work that is going on in the outside world.

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Much is said on the subject of technical education by people who are not qualified to speak with authority. Attention is often directed to Germany and America, and we are told that technical knowledge is the best safeguard against foreign competition. But it will not necessarily restrain amongst mechanics excessive demands for increased wages, or eradicate the evils attendant on trades unionism; nor will it be certain to impart to employers that spirit of industrial enterprise which is more than ever the precursor of success. We do not for a moment mean to underrate the value of technical training, which should be thorough and thoroughly practical, but to it must be added much shrewd common-sense. And this is equally necessary for professional, manufacturing, and working engineers, if the advantages of increased education are to be fully realised.

Architects and Engineering.

DURING the last few months several papers have been contributed to American Engineering Societies and journals upon the subject of the modern high building. Such structures are popular in America because they afford the most concentrated mode of occupation for busy commercial centres. The available area of a business block can be largely augmented by increasing the number of floors, without appreciable inconvenience to the occupants on the score of access, and the concentration of offices upon a relatively small area permits the application of engineering plant for various services at a nominal cost per room.

In its early stage, the high building was crude in design and unscientific in construction. Cast-iron columns and rolled iron beams did not lend themselves to the satisfactory erection of skeleton framework, and it was not until the age of steel had set in that the refinements of engineering construction were exemplified in work of the kind. It has been justly remarked by an American architect, that "To-day the structural possibilities have been developed, but the architectural possibilities have not been realised, because most of the men who have heretofore been entrusted with the design of the exteriors have not been trained to see the glorious possibilities before them—the opportunity to create a new architecture, to give a rational expression to the new materials." This criticism of architecture is merited, for the modern steel building is almost invariably made to stand in the garments of antiquity, pretending to be a masonry structure, yet disregarding the fundamental principles of such work.

Architectural forms of to-day are mere meaningless perpetuations of obsolete methods. Details that were appropriate to buildings of wood were produced in structures of stone, and now the forms suitable for stone are appearing in buildings of material differing more widely from stone than stone differs from wood. The latter condition is especially exemplified in the American steel building, and it has been aptly said that modern American architecture is "the offspring of an illegitimate commerce with the mongrel styles of the past."

True architecture has been dead for hundreds of years, and the present-day designer does little more than to dig down despairingly into the mouldy *débris* of the past, bringing forth features of former triumphs, and attempting to build new structures with worn-out and unmeaning symbols. There is little hope that this state of things will be altered so long as architects are taught design without practical training in construction. At the present time architects do not favour steel-framed buildings, professedly because they are supposed to be contrary to "art," but really because steel construction is not understood. The result is, that a mongrel form of brick and steel construction has sprung up, lacking homogeneity, and of unscientific design and execution. Unhappily, the architect appears to have no ambition to be considered a practical man, and we fear he would feel insulted if termed a builder or even a "consulting builder." That is what he really ought to be, but he is frequently so anxious to prove to himself and the world that he is an "artist," and connected with art of the kind commonly spelt with a capital A, as to be oblivious to the more prosaic details of practical art.

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Misconception as to the practical nature of the architect's true calling is not confined to this country, as the following words by an American architect on the modern high building will indicate :—

"What is the chief characteristic of the tall office building? And at once we answer, it is lofty. This loftiness is to the artist-nature, its thrilling aspect. It is the very openorgan tone in its appeal. It must in turn be the dominant chord in his expression of it, the true excitant of his imagination. It must be tall; every inch of it tall. The force and power of altitude must be in it. It must be every inch of it a proud soaring thing, rising in sheer exultation, that from bottom to top, it is a unit without a single dissenting line, that it is the new, the unexpected, the eloquent peroration of most bald, most sinister, most forbidding conditions."

The foregoing is a very choice specimen of what Mark Twain expressively

terms "hogwash." We should never have thought that the "loftiness" of a "tall" building could so excite the imagination, even of an "artist-nature," as to occasion so incoherent an effusion, and such extraordinary disregard of English grammar. A building exhibiting so many unusual, not to say inconvenient, characteristics, would scarcely be suited for quiet office work, or for the restfulness of home-life. We have been unable to ascertain what the "peroration" of a "bald condition" really is, but no doubt it is a most fitting end for a building endowed with so many restless and objectionable attributes. But what are we to think of the architect who can perpetrate such delirious twaddle, or of his professional brethren who can listen to it with approval? British architects have not yet allowed their thoughts to run riot to such an extent, but the quotation serves to show the danger of giving way to vapourings about "art."

Individual architects and architectural societies will do wisely if they attempt to follow the example set by engineers, who study a living and progressivive science, striving to discover and to understand the principles underlying their work, and to use experience and past errors as stepping-stones to further knowledge.

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The modern building constitutes a most interesting problem, and one requiring much study for its solution. The desired architectural treatment is often at variance with necessary structural details and with utilitarian requirements. Consequently, the most careful consideration to each element is necessary in order that a satisfactory and harmonious whole may be achieved. A confiding public entrusts to the architect the task of designing buildings of all kinds, involving profound knowledge of the builder's art, as well as of other arts and sciences. He is expected to be, but is not, a specialist in steel construction, mechanical, electrical, hydraulic, ventilating, and sanitary engineering, and also in matters such as more properly come within the province of the analyst, the bacteriologist, and the physician. Consequently he must either refuse profitable business or be a sham. Human nature inevitably leads to the latter alternative. Architects who are conscientious, call to their aid the consulting engineer and other experts, but too many adopt the cheaper method of sucking the brains of industrial engineers and manufacturers of specialties, all of whom are only too ready to give gratuitous advice, and to spend money in the hope of securing business without competition. This is usually a vain hope, because the architect obtains plans and specifications on similar terms from half a score, more or less, of rival firms. This is a very cheap and easy mode of education, but it is a monstrous abuse that should be abolished. It is fostered by trade jealousy, but could be put down by the aid of associations, such as those formed for protecting the interests of various professions and trades, whose members are willing to trust each other. By all means let industrial firms lay themselves out to furnish the fullest possible details and information to genuine enquirers, but not to persons who merely wish to acquire for nothing, knowledge that is afterwards retailed at the *ad valorem* rate of five per cent.

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All responsibility rests upon the architect, which is really very absurd, for a man cannot supervise operations entirely beyond the scope of his education. Fire-proof construction is now in very general use, but even the best material cannot protect metal from injury unless used in ample thickness and in forms that provide dead air spaces for retarding the conduction of heat. One reason for the undesirable thinness of terra-cotta coverings used, is to be found in the fact that architects are apt to begrudge every inch required for fire-proof casing. Further, they have become accustomed to the shapes and forms adopted when the material was first introduced, and are not readily persuaded to make alterations. Manufacturers can only be expected to produce goods that are saleable, and if architects will not impress upon clients the necessity for thicker forms of fire-proof coverings, undesirable methods must be perpetuated. Again, no system of fire-proofing is com-

plete unless the exterior as well as the interior of the building is protected by fire prevention apparatus. Perforated distributing pipes should be run outside every high building at intervals, so that in the event of fire on adjacent premises, a sheet of water may be formed over the exposed surface. The interior should be provided with hydrants, chemical fire-extinguishing appliances, and electric fire-alarms. Such apparatus is rarely understood by the architect, and the consequent result is inefficiency.

In America the mechanical features of a building are generally thought out at the time the architectural and structural plans are under consideration. This course is only possible when the architect has the advantage of professional engineering assistance. Even assuming the architect to be a master of building construction, he cannot and does not understand steam generating, power, pumping, heating, hydraulic, elevator, electrical and other plant required in the engineering equipment of a large building. Plant of the kind is rarely found in a complete form in any of the large office and residential blocks of London, or other cities in Great Britain. Heating, ventilating, hot-water, and lift-services are often forgotten entirely, and buildings are so designed that their subsequent addition becomes either difficult or impossible. Some architects seem to imagine that pipes and conduits of all kinds can be run somehow or other after a building has been finished, and so the most difficult problems frequently arise which cannot always be solved in any satisfactory manner.

The fact is, that the modern building requires the collaboration of the architect and the engineer. Considering the number of subjects involved, we do not think it possible for the architect alone to acquire adequate training in all of them. If his education could be made to include an apprenticeship in the builder's shop, and subsequent experience in charge of actual structural work, he would have a chance of becoming at least a real architect, but time could not also be found for training as an engineer. This being the case, he should cease from dabbling in work he does not understand. Then there might be some reason for hoping that modern buildings would be more worthy of the age, and more creditable to all parties concerned.

Original Signed Articles

Propeller-Shafts.

By AN EXPERT.

THAT the screw-shafts of modern steamers have achieved an unenviable notoriety of late years in regard to failures no one in any way connected with the mercantile marine can for one moment deny. Scarcely a column of shipping casualties can be scanned without an entry being found to the effect that the s.s. —— has been towed into some port, more or less distant, with her screw-shaft broken; and those intimately concerned, either in the construction, owning, insuring, or classification, have for some time been giving the matter the most careful and anxious consideration, with the view of finding out a remedy for such a serious state of affairs.

Although great prominence is now given to screw-shaft failures by their very number, it must not be forgotten that these were by no means unknown ten, fifteen, and twenty years ago; instances of vessels breaking their shafts at sea and losing propellers, etc., came frequently in evidence before those who had this particular branch of repairs in hand. What, however, we have to deal with now more particularly is the fact that, whereas the failures were formerly due either to ineffective slabbing, corrosion, or occasional fractures, they now are almost entirely confined to the latter, occurring in the majority of cases in vessels of a very full body, used for general cargo purposes.

Now under what conditions of difference are shafts run in these present days as compared with what prevailed, say, some fifteen to twenty years ago? They appear to be principally three in number—viz. change of form in vessels, and to these being run frequently in ballast on a light draft; three, four, or more, crank engines run without a governor; and change of material.

I suppose the majority of those who have written and spoken on this subject (and their name is legion!) have repeated and emphasised the assertion that our failures are due alone to increase in size and alteration in form of the vessel. That they are partly accurate in the last particular is, perhaps, right; but by no possible form of reasoning can I see that the argument is a sound one which is based on the bulk of the vessel alone being reckoned as an important factor, and I am of opinion that the alteration in form would not of itself be of such serious moment were it not coupled with running in ballast with a partially immersed propeller.

With regard to the second point—viz. continuous running of engines without a governor—it must be remembered that under the old conditions with compounds, it was usual in heavy weather for the

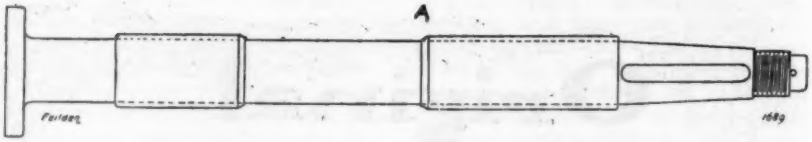


FIG. 1.

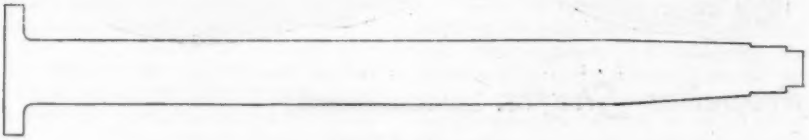


FIG. 2.

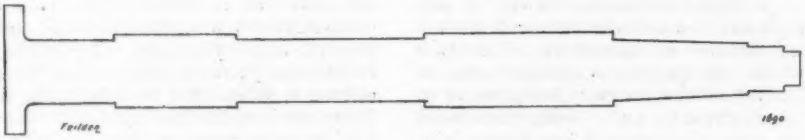


FIG. 3.

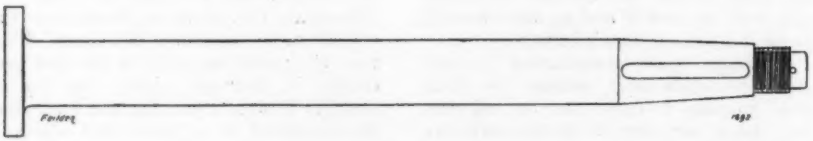


FIG. 5.

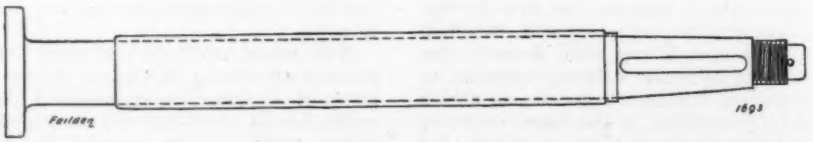


FIG. 6.

governor to be connected, and the engines put under such control that when the propeller took the sea the shock to the shaft was decreased very considerably. Now, however, we have generally abandoned this, and the i.h.p. given out at the propeller is practically the same whether it is working in the air, deeply immersed, or striking the water when the vessel is settling down after a heavy pitch. That this latter is a potent factor in setting up abnormal strains requires neither argument nor enforcement.

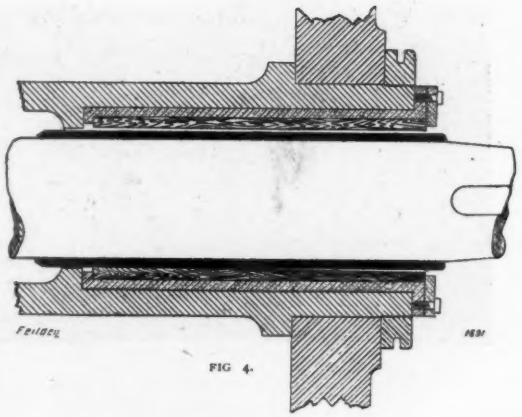


FIG 4.

And now as to material. In this respect, it is considered, the forgemasters and inspectors who are responsible for the manufacture of shaft forgings have good cause for complaint against much of the criticism on this subject. Compare what was the frequent practice, say, twenty years ago, and what we expect to have, and what we really get now. Would it be an exaggeration to say that most of the forgings supplied during the earlier eighties were only a slight remove from crude puddle iron. Those who have broken many of the shafts made about that time, can bear out the accuracy of the statement that the majority would break under a drop test, not only in one, but in two and often more places, from the effect of one blow—the material at the fractures giving an appearance of a mixture principally of a large crystalline nature, and evidencing in an unmistakable manner, that care in the shop, work, and selection of material left very much to be desired. A case in point: The wrought-iron stern frame of a vessel, built by an eminent firm nineteen years ago, fell from the sling on to a hard surface, and broke into eleven pieces. That, of course, was not a shaft, but it will serve to point the moral and its application. The promiscuous use of steel scrap, or a mixture of steel and iron scrap, has been doubtless a weakness in forgings of recent years, but this has had its day, and the extra care now taken in the selection, cleaning, and piling, together with heavier hammers and improved machinery, enables a shaft to be manufactured infinitely better than the majority of those with which it has been often unfavourably compared. A very slight acquaintance with workshop manipulation will prove this, as in the turning and machining the milder and improved quality of the iron now in almost universal use is easily recognised.

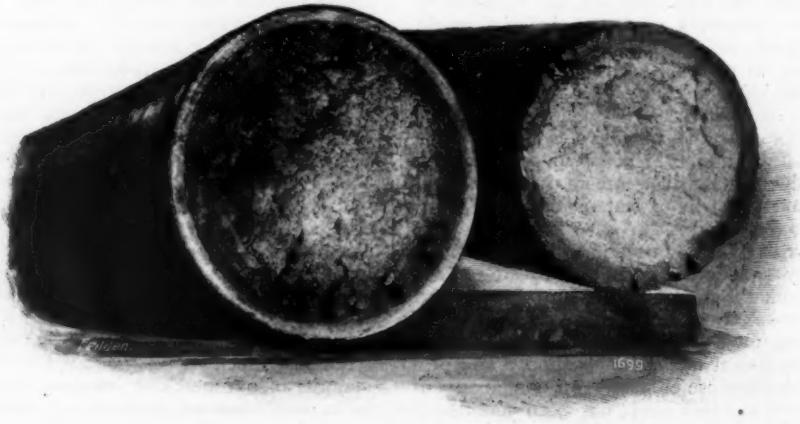
In the writer's opinion, however, the matter resolves itself chiefly into this: in the old type of finer steamers, necessarily of greater draft, the stresses on the screw shaft were nothing like as intense as those experienced in the modern type, and consequently the weakness due to the shafts at normal form (which in itself is almost an outrage to the mechanical eye), even combined as it was with inferior material, was not found out. Now, however, that different conditions prevail, it should be small matter for wonder that trouble, such as is now experienced, has ensued and caused such a considerable amount of enquiry and consideration.

By referring to the sketch (Fig. 1) of a screw shaft, such as can be found in the majority of our merchant steamers, it will be at once observed that it is ingeniously proportioned, with an abrupt change of form at the exact point *A* where the

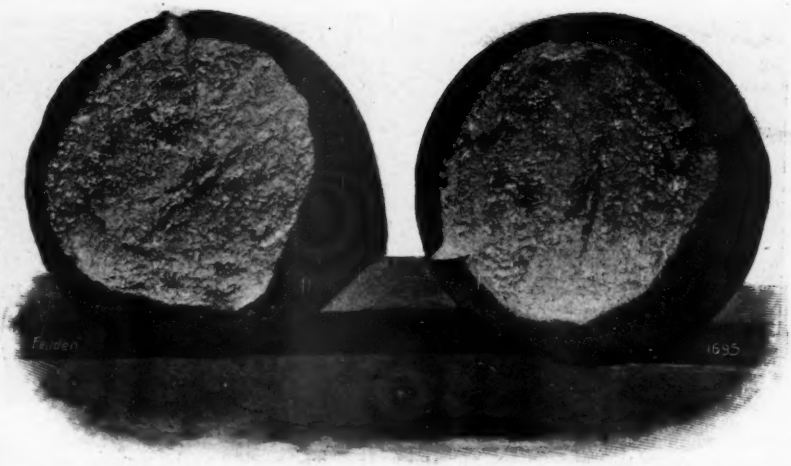
SHAFT WITH LINER CUT OFF SHEWING LINE OF FRACTURE.

principal stresses and where the harmonic torsion and the harmonic resistance to torsion are concentrated. It is also considered that the gunmetal sleeve, by being shrunk on, locally strengthens this part of the shaft over and above what is due to its diameter, in the same way as the coils do which are shrunk on an Armstrong gun. A simple way to demonstrate the torsional weakness of this structure is to take two pieces of very thin tin (Figs. 2 and 3) cut to the shape of a shaft, one with liners and without, and then twist them; the first, with very little extra strain, will shear itself through at the shoulders, while the other will twist quite uniformly and symmetrically.

The taper of the wood in the stern-bush is a matter also that has received very little attention in dealing with this question; as, however, this is frequently found worn from one-eighth to a quarter of an inch more at the after than at the forward end, the enormous amount of additional work which such a consideration entails must be, and is, a source of great addi-



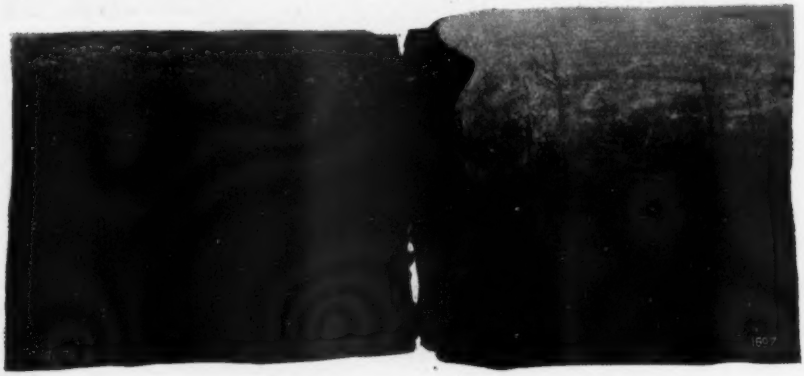
SHAFT BROKEN IN ORDER TO SEE EXTENT OF FRACTURE.



SHAFT BROKEN IN ORDER TO SEE EXTENT OF FRACTURE.

tional fatigue This will be better appreciated by referring to Fig. 4, and in regard to this it may also be noted that the added work on an ordinary shaft running, say, three-eighths of an inch slack is in itself about 25 per cent. over and above the normal stress.

That the majority of shaft failures occur at the point where the fore-end of the stern-bush and the after-liner are coincident, can, therefore, be no matter for surprise, those that gave way at the after-end being quite a small proportion, although the fractures necessarily partake of a similar character. By referring to the accompanying photographs, the nature and extent of these will be seen very clearly.

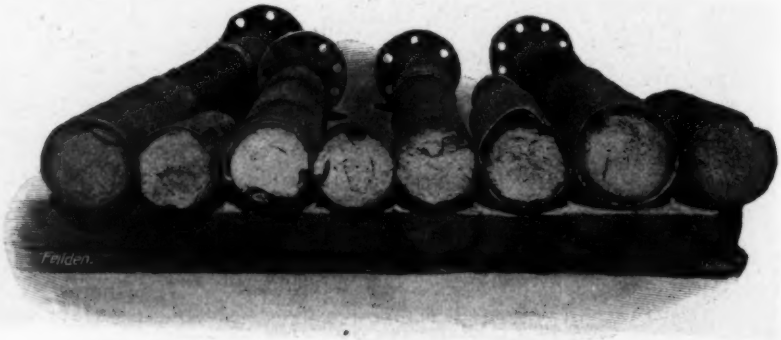


SHAFT FITTED WITH SLEEVE WITH CORRUGATED END, SHEWING HOW FRACTURE FOLLOWS THE ALTERATION IN FORM.

SHAFT FITTED WITH SLEEVE WITH CORRUGATED END, SHEWING HOW FRACTURE FOLLOWS THE ALTERATION IN FORM.

Having thus briefly treated on the defects of the shaft as a structure, and of the conditions under which it is run, it may, perhaps, be expected that the various panaceas will now be enumerated which have been tried to obviate this evil; to attempt to do so, however, would be to extend this article to an undue length; suffice it to say, then, that general attention has now been called to many matters that have been often neglected, including the need for frequent adjusting and examination, the use of oil instead of water, etc. etc. The suggestion of a return to the old outer bearing has been very coldly received, owing to the general recognition of the fact that the force of the vibrations from blows on the rudder destroys its efficiency.

The remedy, it is thought, is not an easy one, nor will be found so long as the system of running the present type of vessels in light ballast trim prevails in our Mercantile Marine; still, it is considered that much may be done to, at all events, decrease the number and extent of mishaps. With regard to many of the present ships that are running, it is certain that their shafts, designed on the old plan, are a comparative failure, and it

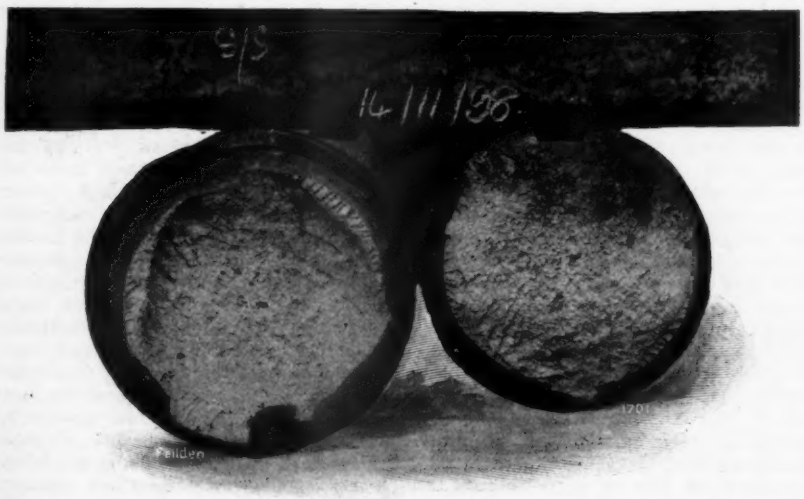


A GROUP OF SHAFTS BROKEN IN ORDER TO SEE EXTENT OF FRACTURE.

seems incomprehensible that so many are duplicated, when they are found defective time after time in the same place and no consideration given to such dearly-bought experience. It is difficult to persuade those interested that increase of size is in itself no certain panacea, and that without something abnormal in this way it is not here we must look for the solution; for hard facts show unmistakably that a very large margin, indeed, over any calculated size is not a valid protection.

We must thus perforce try some, what may be termed, palliative measures, and here we have a varied, though restricted, field, with a certain amount of satisfactory experience to work from.

A parallel shaft of iron, well made and run in oil, is undoubtedly the best that



SCREW-SHAFT BEFORE AND AFTER BREAKING, SHEWING FRACTURE AT AFTER-END OF AFTER-LINER.

can be used under existing circumstances. It should have a long white-metal or cast-iron bearing, and with a propeller as light as possible, having little overhang, *i.e.* fitted close up to the stern tube. A shaft with a continuous liner is also valuable, but only when the liner is made to fit into the propeller, as shown in Figs. 5 and 6, otherwise it has the defect of a break in the continuity before alluded to. No difficulty is found in the manufacture and fitting of the liner, which is frequently made up to 15 ft. in length and drawn on cold.

Shafts of these designs made of good material and run under the usual conditions are doing good work, and it is believed will do much to take away the reproach now attached to this part of our marine engines. The new rules formulated by Lloyd's Register by introducing the propeller diameter as a direct factor in the size of the shaft, and also penalising the older and more obsolete designs, will do more towards general improvement than all the irresponsible suggestions that can be made.

As was stated at the commencement of this article, we have been, and always must be, in the nature of things, liable to accidents to our shafts; latent defects, errors in manufacture and in fitting and securing, can never be eliminated, but much can be done in the way of improved design to mitigate our present trouble, and the increase of those made on the lines indicated above appear to forecast a better time for all interested.

Electric Pumping in Great Britain.

By I. W. CHUBB, A.M.I.E.E.

Of the numerous examples of electrical machinery none has been more consistently successful than the electric pump. Again, of pumping plants, nowhere is the electrical system of greater use than in connection with mining, where the ease of installation and general adaptability of the system are especially advantageous. Of the convenience of electrical pumping plants when properly designed, of their readiness to meet sudden emergencies, a classical example was furnished at a comparatively early stage of the usage of the system, by a performance of the machinery installed by Messrs. Corlett of Wigan at East Howle Colliery, Durham. Here a large feeder threatened to drown out a seam by breaking away at one of the pits; and the pumps had to run, with a short stoppage to change the brushes of the motor, for 82 hours at a stretch. Similar examples of a more recent date could readily be quoted if it were worth while.

The competitors in the transmission of energy in mines to be faced by the electrical system include the hydraulic and pneumatic systems. Steam plants have been used, but the condensation loss due to radiation from the pipes and the other losses are often simply enormous. Again, on the hydraulic system water can be used only where it can be drained away; and with pneumatic transmission, unless the velocity of the air is kept low, the loss by friction in the pipes may put the system out of consideration. Pumps driven by endless wire ropes, running over guide pulleys, although sometimes used for underground work, need not be specially considered, the cost of working and upkeep being excessive. Roughly, with the principal systems, the initial cost would be equal, but the working expenses and maintenance charges generally should be least when an electrical system is employed. On this point it is, perhaps, difficult to cite actual cases taken from machinery erected in this kingdom because an electrical plant usually simply replaces one of the other systems, the machinery of which, being old, is more inefficient than present-day plant of similar kind would be. Your mine manager in many cases changes his machinery slowly; and, like Stevenson's hero, thinks that he will "go to hell like a gentleman with his ancestors." However, one case may be instanced where a Corliss engine was used to drive a 50-unit dynamo; there were seven electrical pumps, each of about the same power. The substitution of the electrical system for an endless wire-rope system saved about 20 tons of coal a week, almost two-thirds the consumption, the attendance necessary being reduced by two men and two boys. This is, perhaps, an exceptional case, but at any rate it tends to show what is, from other points of view, fairly obvious, namely, that in many mines it would pay to change from the present old-fashioned system to an electrical system.

However, a mere saving in the fuel consumed for a mining engine is not of tremendous importance to the coal-mining engineer: his fuel is so cheap that the point hardly concerns him. But a feature that will appeal to all is the ease with which the generator and motor can be connected. Between the electric and other systems it is unnecessary to write of the difference in the facilities with which the machinery may be fixed—it can be safely said that an electric motor is placed in position at least as readily as any other motor—but the comparative ease with which an electric cable can be fixed will be appreciated by all who have to deal with the erection of pipes on shifting floors, roadways, etc. Repairs are effected at least as easily as with other systems, branches are readily connected, losses in bends are avoided, and the cables occupy

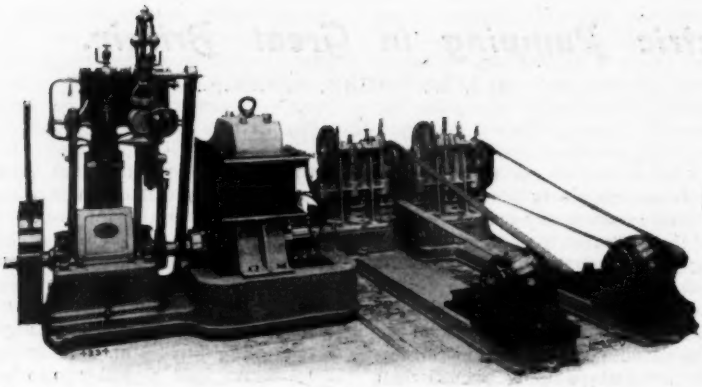


FIG. 1.—ENGINE, DYNAMO, MOTORS AND PUMPS, AS SUPPLIED TO BECKWORTH COLLIERY.

less space in the ways than steam or water-pipes. Again, if the cables are overhead, supported from the roof, as they often are, it is only necessary to leave a slack between the supporting insulators to prevent a breakage that otherwise might occur at a fall. The wires can, of course, be cleated to the uprights along the roads. Further, it might be supposed that in the event of a break, or for other reasons, arcing would fire the timbers of a mine; this, however, as far as the writer knows, has never occurred, or rather no really serious accident has resulted from such arcing. For these, and for other reasons, electrical pumps and electrical machinery generally will be found largely in use in mines.

The early history of electric pumping has been detailed elsewhere by the present writer, but the following sketch may possibly be of interest. The earliest electric pumping plant in this country was erected at the Trafalgar Colliery, Forest of Dean; this, however, was not absolutely the first in use anywhere, for in June 1873, at the Machinery Hall of the Exhibition at Vienna, a centrifugal pump was driven from an electric motor by Fontaine. Also in July 1881 a Gramme machine was used at La Rochelle waterworks to drive a rotary pump through friction gearing. The motor was about 850 yds. from the dynamo, the lines being carried overhead by means of telegraph poles. The dynamo ran at 1,300 revolutions per minute and the motor at 800 revolutions, about 30,000 gallons of water per hour being lifted 6 feet.

The plant at the Forest of Dean was erected by the Pyramid Electric Co., and commenced working at the end of 1882. The dynamo was fixed at the surface some short distance from the engine house, and the installation was intended by Captain Blanche Brain to deal with an accumulation of water in the dip workings. The motor first laid down was of about 1½ h.p., this was increased by the addition of a 2½-h.p. plant in 1886, at a part of the mine 800 yds. from the engine, and by an addition of about 30 h.p. in 1887. The last extension was for the main pumping plant. As the crank shaft of the pump, with a double plunger, made 25 revolutions per min. to 1,250 revolutions of the motor, a considerable speed reduction had to be effected, and for this purpose leather link belting on the motor pulley and spur gearing on the pump were used. The water was lifted 300 ft., and the efficiency of the system, as expressed by the ratio of net power required for lifting the water and the indicated power of the engine, was 35 per cent. More than half the loss occurred at the engine, 17 per cent. in the line, 10 per cent. in the pump, and the rest at the dynamo and motor.

The electrical plant was supplied by the Elwell Parker Co. of Wolverhampton, and the mechanical portion by the Lillieshall Iron Co.

The next mining plant was erected at Dalkeith, at the Marquis of Lothian's Colliery. The contractors were the Electro-Carbon Storage Co., Leith, a Higg dynamo being used above ground, and a similar motor, with pump attached, below ground. A pumping plant was installed at a coal mine near Vienna, in 1883, Gramme machines being used, the output of the generator being 7,500 watts—15 amp. at 500 volts. In addition to a saving of fuel, the electric pump reduced the temperature of the gallery—the main reason for the replacement of the steam plant.

In 1885, the first of the celebrated Normanton plants was supplied by Messrs. Immisch & Co. for Messrs. Locke & Co.'s St. John's Colliery. It is unnecessary to describe the installation; this has been done several times. It will be sufficient to say that a pair of differential pumps by Messrs. Baddeley & Co., of Wakefield, were driven from a main shaft running at 8 revolutions per minute. As the speed of the motor was about 650 revolutions per minute, the speed reduction was in ratio of more than 80 to 1. A 10-in. belt (on the motor pulley) and countershafting, with mortised and cast-iron gearing, formed links in the transmission scheme. The output of the Immisch dynamo was about 48 amp. at 170 volts, the efficiency, expressed as suggested above, being 44 per cent. Several extensions were effected by Messrs. Immisch & Co., and by their successors, the General Electric Power and Traction Co., Ltd., the potential at the dynamo terminals being also increased to 600 volts, while three-throw pumps were employed. Among the objects of the extensions was the coping with a salt feeder, 90 ft. below the surface, one lift only being employed, while dip pumpings, 2,500 yds. and 3,000 yds., in bye, were also included in the work. An interesting electric pumping plant was ordered in 1888, by Lord Vernon for the water supply of Poynton, Cheshire. The plant, erected by Messrs. Stanley & Davis, of Hyde, consisted of a dynamo and engine, the motor being at the top of a well, and running at 800 revolutions per minute. The reservoir was about 2½ miles distant,

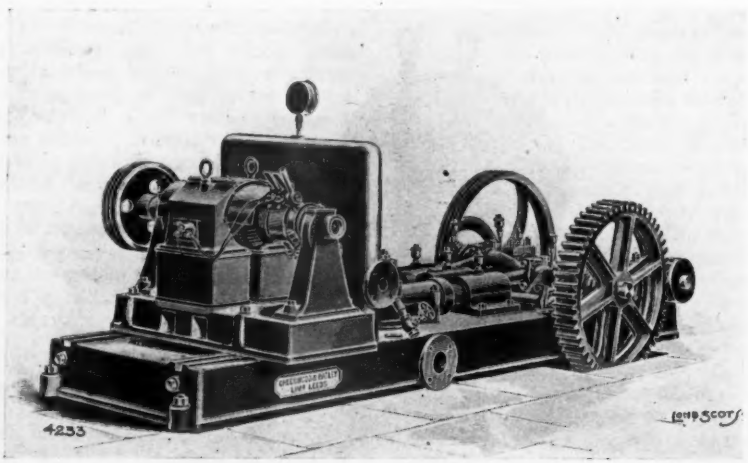


FIG. 2.—HORIZONTAL THREE-THROW ELECTRICALLY-DRIVEN PUMP, AS USED FOR DEALING WITH LARGE VOLUMES OF WATER.

and about 1,200 gallons of water were sent to it per hour by a two-throw pump with $3\frac{1}{2}$-in. rams by 9-in. stroke.

Details of the further history of electric pumping need not detain us, the system now being in use for brewery plants, circulating pumps for the condensing plant of steam engines, for iron works, for irrigation and sewage works, for working lifts, for the supply of public water, and of water under pressure for fire-extinguishing purposes in America, at least, and for feed pumps for boilers, in addition to mining purposes.

For electrical purposes, as a rule either three-throw pumps or centrifugal pumps, depending on the head, are employed. The turning moment of a continuous or direct current electric motor being uniformly of one value throughout a revolution, it follows that the pump offering the most even resistance when doing its work, will be of the most suitable type. For this reason, of reciprocating pumps, the three-throw type is best ; with it the variation of resistance from the mean value in one revolution is only about 5 or 6 per cent. Plunger pumps with outside packings adjusted by glands have always been a favourite form for mining work, because, while the damage done by any grit that may be in the water is not great, leakage is detected with comparative ease. Small pumps are often vertical, as in Fig. 1, which shows the engine and dynamo and pumps and motors supplied to Beckworth Colliery, but for dealing with large volumes of water, horizontal three-throw pumps, as Fig. 2, are generally employed. It has been suggested that considerations of the head of water against which the pump is to work, should govern, to some extent, the position of the plunger ; and that for heads exceeding 300 ft., horizontal pumps only should be used, either horizontal or vertical pumps, as better fit circumstances, being used for heads of lesser value. The field of action of centrifugal pumps is generally, though not necessarily, restricted to heads of less than 30 ft. These pumps are especially useful for condensing plants, and for draining areas to the dip.

The method of transmitting the motion of the armature of the motor to the pump depends on the relative speeds of revolution. With a comparatively fast running pumping plant, such as is afforded by a centrifugal pump, a low-speed electric motor can be coupled direct, the two

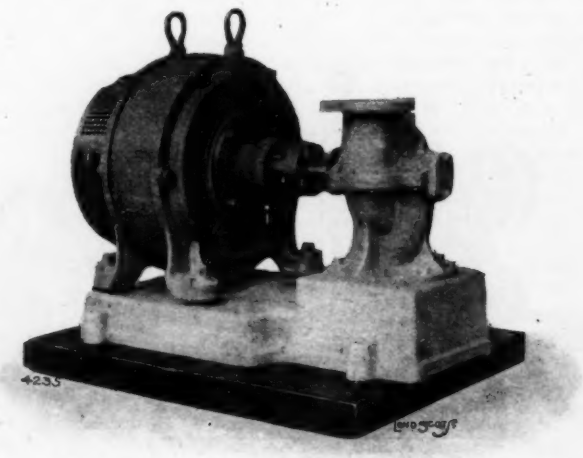


FIG. 3.—CENTRIFUGAL PUMP COUPLED DIRECT TO MOTOR.

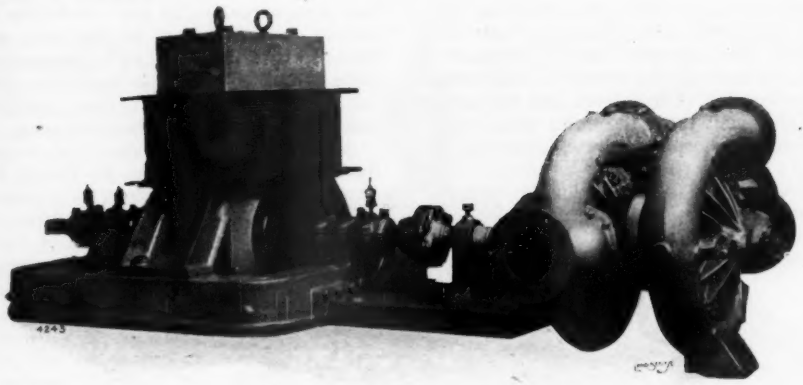


FIG. 4.—AN EXAMPLE OF MOTOR-DRIVEN TWIN CENTRIFUGAL PUMPS.

being placed on a single bed plate, as in Fig. 3, which shows an enclosed motor by Crompton & Co., Chelmsford, or the pump may, if desired, be overhung, as in Fig. 4, where the twin centrifugal pumps and motor supplied by E. Scott & Mountain for the Clay Lane Iron Co.'s Ironstone Mines, Yorkshire, are illustrated. This, however, is not generally possible with reciprocating pumps, the crank shafts of which often do not make more than 25 revolutions, and very seldom reach 75 revolutions a minute. The minimum convenient speed of an electric motor being placed at about 500 revolutions a minute, it follows that the velocity ratio of the gearing to be interposed between the motor and the pump is quite likely to be of a value exceeding 20. Therefore, in some of the earlier plants, a belt with a double system of spur gearing was employed, the system being, however, quickly reduced to two steps using spur gear only, as in Fig. 5, or a belt and spur gear as in Fig. 6. The system may be simplified even to a worm and worm wheel only, as in Fig. 7, which shows boiler feed pumps. The pump, gearing, and motor are often placed on a single bed-plate, but for mining purposes it is sometimes an advantage to have the bed in sections of a small size, as in Fig. 8, so that the parts may be readily placed in the pit before being bolted together. Where belts are used they are of leather link or cotton, and Fig. 9 shows a means of obtaining a long drive with general portability. The gearing may be of a plain spur type, the wheels being shrouded, or better, of a double helical form, as in Fig. 5. Here a Hayward-Tyler horizontal three-throw pump is shown, the motor, made by the Electric Construction Co., Ltd., Wolverhampton, having its field coils lagged with sheet steel to prevent damage to the winding, and the armature and commutator are enclosed in a gas-tight box, so that the machine might work in a fiery mine. Pinions used on the armature shaft of the motor have been made of gun-metal, vulcanised fibre, and of alternate laminations of steel and fibre, the plates being bolted firmly together, and to a gun-metal bush. The object of using a fibre pinion is to eliminate noise as far as possible, the composite pinion being used for a like purpose, with additional strength. It is generally preferable, where possible, to effect the first reduction by means of ropes or belts; this, of course, prevents the motor receiving jars or shocks. A single-reduction gearing usually consists of a worm and worm wheel, a system generally considered by engineers as necessarily inefficient. Messrs. E. Scott & Mountain, Newcastle-on-Tyne, who have made many electric pumps with

worm gearing, and who, moreover, have probably had more experience with such plant than any other firm of engineers in this country, used generally to case-harden the worm, if of mild steel, and then grind it absolutely true; the worm wheel rim is often of phosphor bronze, with teeth cut by a special process for accuracy This firm endeavour to use double or treble worms running in an oil bath for continuous lubrication, and the end thrust present with the worm gear is taken by

feed pumps, running at 400 revolutions a minute, are, however, to be seen at Bristol, where a pair of such pumps are placed in line on a single bed-plate, with the motor between them, claw clutches making the connection when necessary.

A somewhat curious system is in use at the Compagnie des Mines de Blanzy, in France. Here a synchronous three-phase, Thury-pattern motor of 65 h.p. drives a reciprocating pump by means of connecting rods actuated by two worm wheels

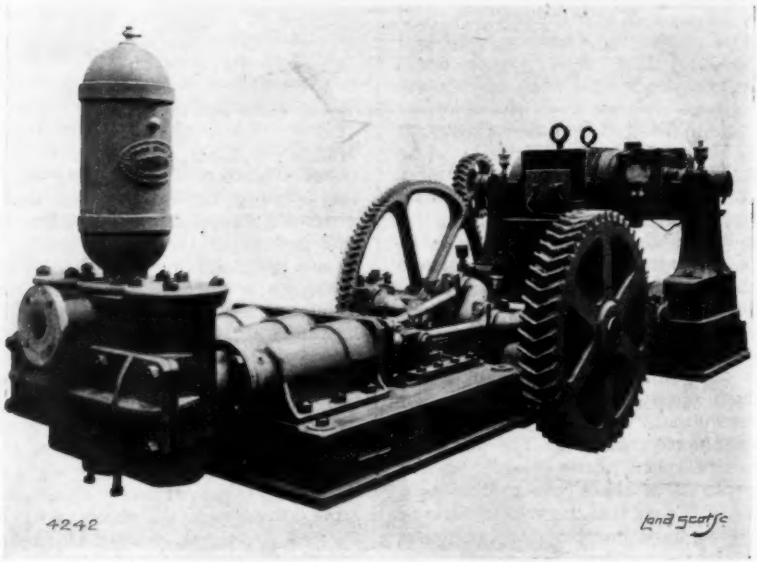


FIG 5.—METHOD OF SPEED REDUCTION BY TWO-STEP SPUR GEARING.

thrust collars on the shaft, always without undue heating. The same firm has also used ball bearings for this purpose, and, regarding these gears generally, they state that a set has been running at North Seaton Colliery, 8 years, for 23 hours a day, transmitting 20 h.p., without any apparent sign of wear. They design their gear on the basis of a bearing, allowing a pressure on the teeth suitable for ordinary high speeds. Direct-driven three-throw

together. Two worms, right and left handed, are on a spindle that is driven from the motor shaft by a magnetic clutch. Each worm drives a wheel at the same speed, and end thrust is thereby avoided.

The dynamos on the surface should if possible be direct driven; little need be said about that point in this article.

The electrical equipment of pumping plants in Great Britain is not complicated

For ordinary sets, consisting of a single dynamo and motor attached, series windings are often used on both of the electrical machines; and Messrs. E. Scott & Mountain, who have, of course, put down many such installations, have found this system very satisfactory. One objection to the series-wound dynamo is that, to prevent failure of the field excitation, an auxiliary method of regulation may be necessary. For this reason a shunt-wound dynamo is sometimes preferred and where several motors working at different speeds and at various times are employed, this form of winding or a compound dynamo should be used with shunt motors. The last keep, within limits, a constant speed at varying loads. The chief value of a series-wound motor is usually held to lie in its power to start on load; this type of machine will not, however, run at constant speed with varying loads. With shunt-motors the starting switch must close first the field circuit and then the armature circuit, this being done gradually through a regulating resistance which is cut out when the required speed is attained by the motor. Similarly a series motor should have at starting a resistance in series with the armature, this being gradually cut out.

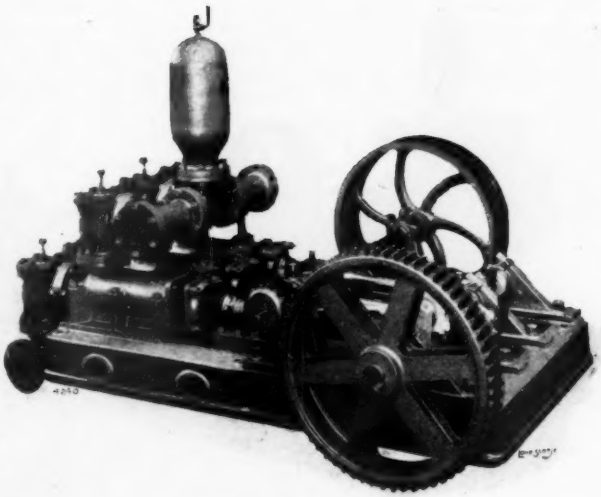


FIG. 6.—SPEED REDUCTION BY BELT AND SPUR GEAR.

Scott & Mountain's special regulating switch, with interlocking shunt-switch for motors, is illustrated by Fig. 10. To regulate the speed of a shunt-motor a variable resistance may be placed in the

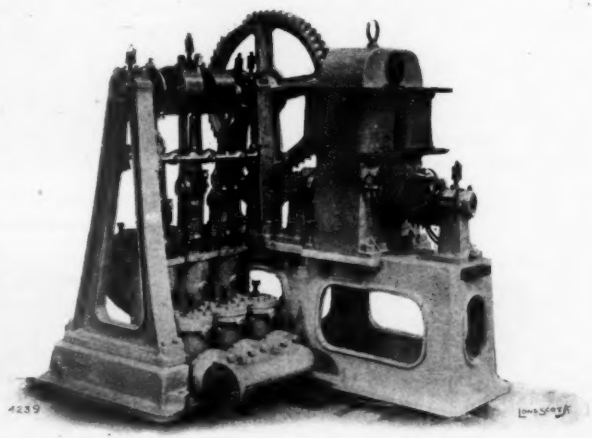


FIG. 7.—SPEED REDUCTION BY WORM AND WORM-WHEEL.

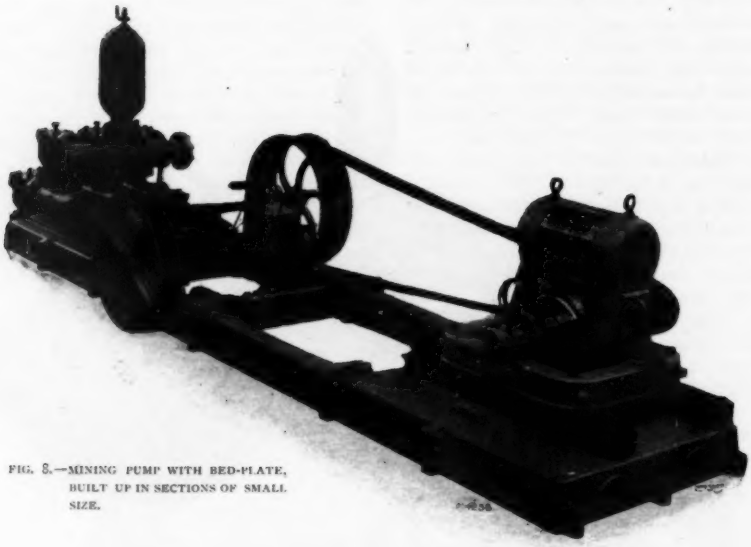


FIG. 8.—MINING PUMP WITH BED-PLATE, BUILT UP IN SECTIONS OF SMALL SIZE.

field circuit, this enabling a considerable increase of speed to be obtained without sparking, if the machine is well designed and wound to give normally the lowest speed without regulation of the resistance.

For transmission over an extended area, where several machines are at work, a compound dynamo should be used so that, notwithstanding changes in the load a constant e.m.f. can be maintained at any given point. Then any of the three types of continuous-current motors, shunt, series, or compound, can be used, and cables may be connected up for power required temporarily only. Compound-wound motors can be designed to run at constant speed with varying loads, but this type is not greatly employed. The usual e.m.f. for pumping plants, especially in mines, is 500 volts. This, though not dangerous to the lives of the majority of persons, is capable of giving a very severe shock; but the current required to kill has apparently no settled standard value, seeming to depend entirely on the individual, and the resistance of the subject may be so low that an e.m.f. of about 200 volts is fatal. Of course, the risk of shocks arising from defective insulation, etc., is one of the chief objections to the use of electricity,

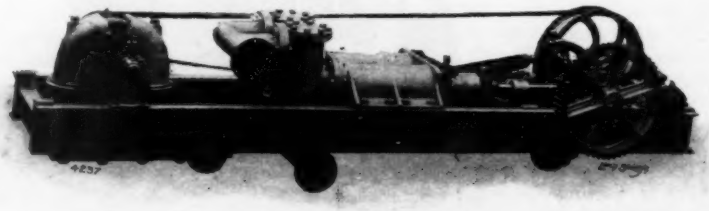


FIG. 9.—AN EXAMPLE OF HOW A LONG DRIVE MAY BE OBTAINED WITHOUT SACRIFICING PORTABILITY.

and another objection in mining work, is the danger of short circuiting at the armature, or of sparking at the commutator, thus causing an explosion in the mine. To prevent this, the armature, commutator, and carbon brushes may be enclosed in a dust-proof and gas-proof casing; or the commutators and brushes only may be enclosed, as in Davis & Stokes' system, where the brushes bear on the inner face of the commutator ring, and are enclosed in a casing with flame-tight joints and with windows for inspection. The motors in use in Great Britain require continuous or direct currents; but, if alternating currents were employed, the great advantage would be that the machine need not be "compassed about with sweet observances" of the commutators. Where a lighting load is to be run in connection with a pumping plant a three-wire, or even a five-wire system of distribution would be suitable for very large installations, while for smaller plants motor-generators can be employed. The current may be taken from the main switch board at the surface to a distributing board at the bottom of the pit.

The chief advantage of an electrical system is its economy in the transmission or power between points a great distance apart; but the pumping installations in this country do not, at present, offer examples of long distance transmission, two miles being about the limit. Of course, this has been exceeded many times on the Continent and in America; in the latter the electrical plants for town supplies of water are not uncommon, and it has been suggested to replace high-pressure water

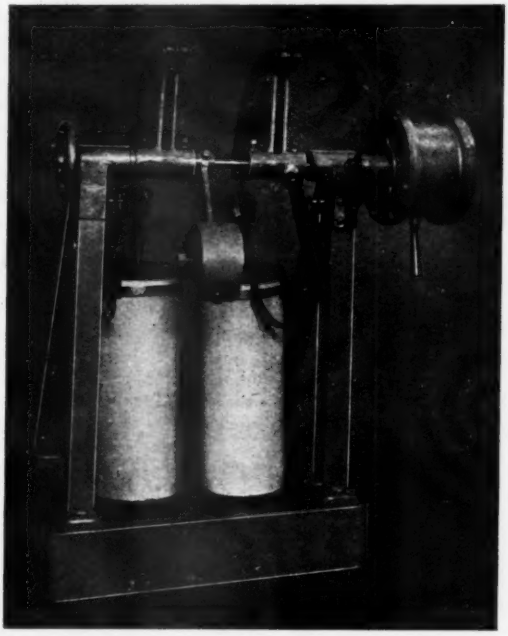


FIG. 10.—SPECIAL REGULATING SWITCH WITH INTERLOCKING SHUNT SWITCH.

mains for houses at elevated positions by electric pumps that lift the water as required from the low-pressure mains, the pump-motor being supplied with current from the public mains, or from a generator placed at the chief pumping stations. The simplicity of the system, the absence of noise and smell, and of difficulties in working the small machinery necessary, are all advantages that can be claimed for electrical methods; and, for mining work, the portability of the plant, its freedom from danger when properly designed, even in fiery mines, would still further recommend the system, even when the distances of energy transmission are short. The overall efficiency of the electrical system may possibly reach 70 per cent., while with compressed air in mining an efficiency of 50 per cent. is about the maximum, this falling to 30 per cent. if the air is not heated previous to use in the motor. On the score of efficiency, therefore, the electrical system has nothing to fear.

J. William Chubb
4244.

High-Speed Engines.

The Influence of Governing on Torque.

(Single Cylinders.)

By J. H. DALES, A.M.Inst.C.E.

(Continued from page 437, Vol. VI.)

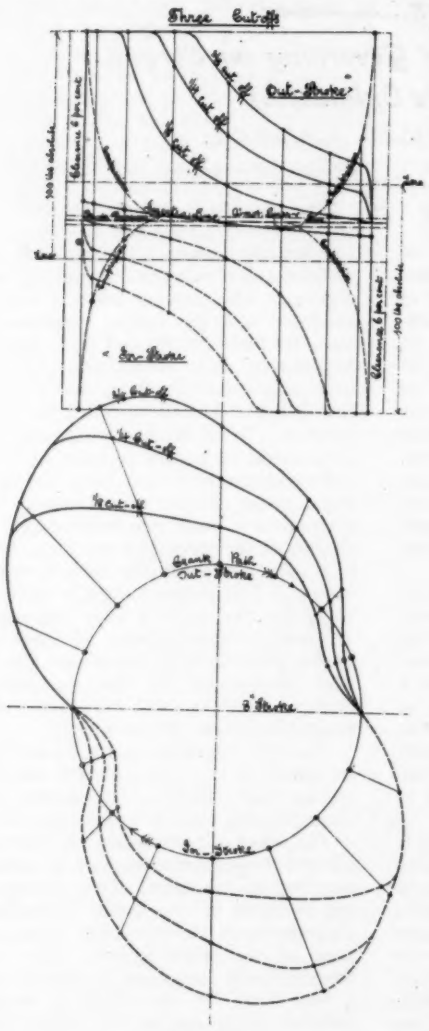
In the consideration of the design of an engine for any given service it is often very helpful, especially in the rush of ordinary business, to have some worked-out results from assumed conditions to guide the judgment of the designer; in fact, to have a sort of ready reckoner or table which will indicate the whereabouts of such proportions as are likely to produce the results which the designer desires. The absolute beginnings or bases of things are often so very obscure in mechanical matters, in fact they may, perhaps, be said to be almost generally so, that tabulated matter, for the general practitioner, is usually the only available source of information. It is this consideration which leads the writer to put the effects of certain assumed conditions of speed, weight, and pressure into graphic form, so that a simple inspection of figures may convey to the enquirer a sufficient amount of information for general purposes, and which will indicate the direction in which the pursuit of exact enquiry is most likely to be profitable.

In order to clearly illustrate the effects of governing on torque, and incidentally on the mechanical action of engines, eight pairs of diagrams have been prepared; four to show the tangential forces due to cut-off governing, and four the same of throttle governing; all under similar conditions of weight, pressure, and speed, and at widely different speeds, so that the resulting actions may be the more striking and the principles involved more clear.

Also, in a graphic form to show the relative work economies of governing by the two systems. Such illustrations might, of course, be multiplied indefinitely to show effects of various combinations. The examples taken are of ordinary proportions and conditions for single-cylinder engines. The pressure taken is 100 lbs. absolute, and the steam diagrams are made for three cut-offs and three throttles respectively, such as constitute an ordinary range—namely, $\frac{1}{5}$, $\frac{1}{4}$, and $\frac{3}{8}$ cut-off and $\frac{3}{4}$ cut-off (fixed) throttled to $\frac{3}{4}$ and $\frac{1}{3}$ power. In all cases it is assumed that there would be a back pressure of 2 lbs., and compression is provided for up to initial steam pressure in all cases. The diagrams are made non-condensing; the clearances are taken at 6 per cent., which is about correct for the best design of engine. The cylinder area is taken at 86 sq. ins., the stroke at 8 ins. (·333 radius of crank), connecting rod $2\frac{1}{2}$ lengths of stroke, and weight of piston-line 250 lbs. The proportions are from a practical example, which ran with remarkable effect at 450 revolutions per minute.

The four diagrams in each set are made for speeds of 150, 300, 450, and 600 revolutions per minute; the inertia lines corresponding to those speeds respectively.

The effect of compression is plotted at the end of each stroke diagram by verticals standing on the inertia lines, corresponding to those of the actual compression diagram upon the base lines (back pressure) of the steam figures. The curve formed by the compression verticals forms a new base for the effective pressure verticals rising out of the inertia lines, which in the torque diagrams produce the tangential resultants, plotted radially on the crank path. It will be observed that the effect of compression materially modifies the terminal effect of momentum of the parts or piston line. The out-stroke steam diagrams are shown in strong full



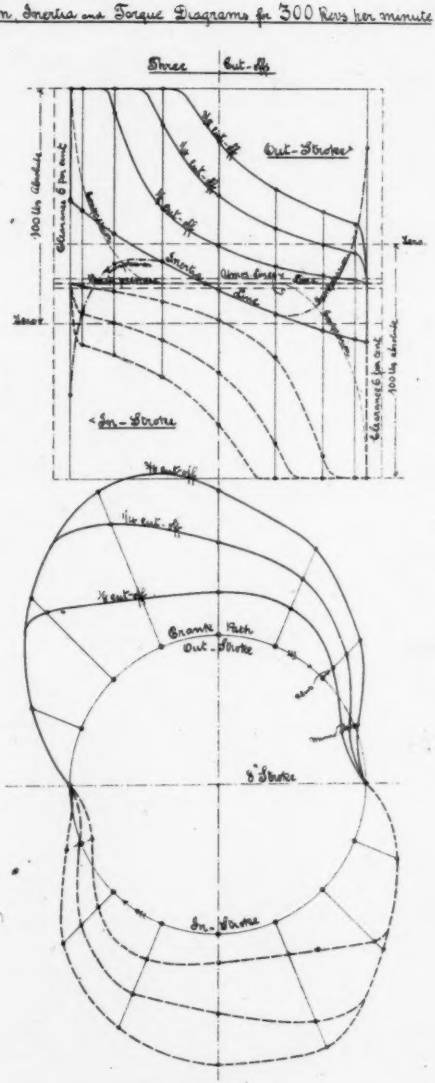
FIGS. 1 AND 2.

lines, while the in-stroke diagrams are shown in strong single-dotted lines. The inertia lines are in full, and serve for both strokes, being of course reversed to the respective steam diagrams. As has been before stated, there is a considerable difference in out- and in-stroke effects from the same steam diagrams.

Taking the first pair of steam and torque figures (1 and 2) respectively, which are constructed for 150 revolutions per minute (a low speed), and cut-off governing, it is seen that there is a preponderance of turning power on the crank in the early part of the stroke, and that for about the first two-eighths of the semi-revolution of the out-stroke, the tangential force is the same for all the cut-offs, but that there the early cut-off line leaves the general curve and becomes of less and less value to near the end of the sixth eighth, when it crosses the crank-path circle, and thenceforward becomes a negative quantity, which would change the pressure on the crank from the pushing to the pulling side of the connecting-rod eye (a correct action if not excessive), and would prepare for the reception of the initial steam pressure for the return stroke. The next long-pressure curve which corresponds with the cut-off leaves the general curve towards the end of the third eighth, and follows a similar course to the $\frac{1}{8}$-cut-off, but crosses the crank-path circle, and becomes negative towards the middle of the seventh eighth; and its opposing force to the piston motion would be a less proportion of the steam diagram, being better in practical effect than the earlier cut-off result. The outside line of the out-stroke curves corresponds to a $\frac{2}{8}$-cut-off, which, while having the same effect on the crank in the early part of the stroke as the other two cut-offs, gives still less difference of negative effect at the end of the stroke, and is altogether more uniform. Half-stroke cut-off, if carried out, would give a still better turning result, but the exhaust pressure would be unduly heavy.

The lower dotted set of steam diagrams corresponds to the dotted curves below the crank-path line, and belong to the in-stroke of the piston. There is a bulging of the curves in the torque diagram of this set, towards the latter end of the stroke, which indicates an increase of tangential effect which compensates for a deficiency in the early part of the same; for, as all the steam diagrams of the in and out-strokes are the same, the power developed on both strokes must be the same, the connecting-rod and inertia effects making the difference in the form of the curves at given corresponding points in the in- and out-stroke figures. The negative effect of the compression differs a little in these (Figs. 1 and 2), but is less striking than in the following figures. In these figures (1 and 2) also, although the actual negative effect of the compression is greater to the out-stroke than the in-stroke, the negative effect on the crank is less on the out-stroke than the in-stroke, by reason of the inclination of the connecting-rod being minus on the out-stroke and plus on the in-stroke.

Figs. 3 and 4 are similar steam diagrams and tangential pressure radials to Figs. 1 and 2, but are made to illustrate the effects of 300 revolutions per minute. The inertia line is seen to be much higher and lower at the beginning and end of the strokes than in the earlier case. As before, the compression curve verticals are plotted to stand on the inertia line, and their negative effects cut off the ends of the steam diagrams, and have a minus result on the crank, but later in the stroke. In this case, by reason of the more pronounced difference of the ends of the inertia line to the horizontal base-line of the steam diagrams, the minus effect is a greater quantity at the end of the out stroke than the in, and also commences earlier in the out-stroke. These



FIGS. 3 AND 4.

diagrams as a whole are an improvement on Nos. 1 and 2, the turning being more uniform and the compression less objectionable. At the same time, it is evident

Steam, Inertia and Torque Diagrams for 450 Revs. per minute

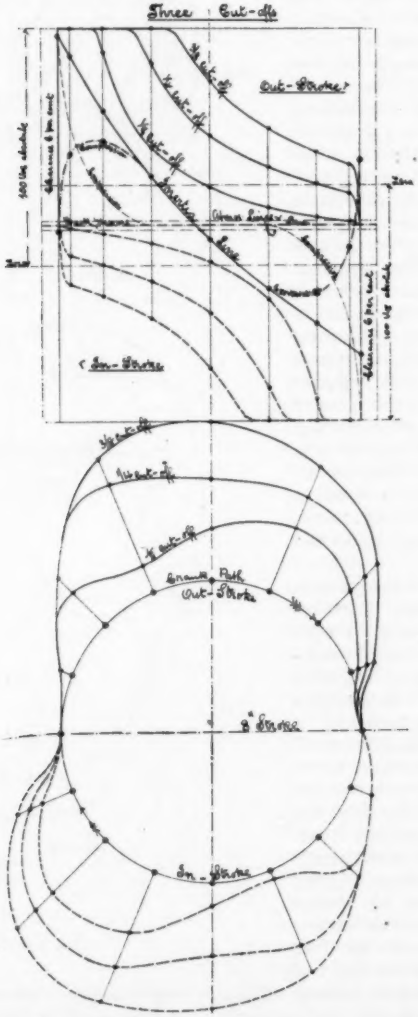


FIG. 5.

FIG. 6.

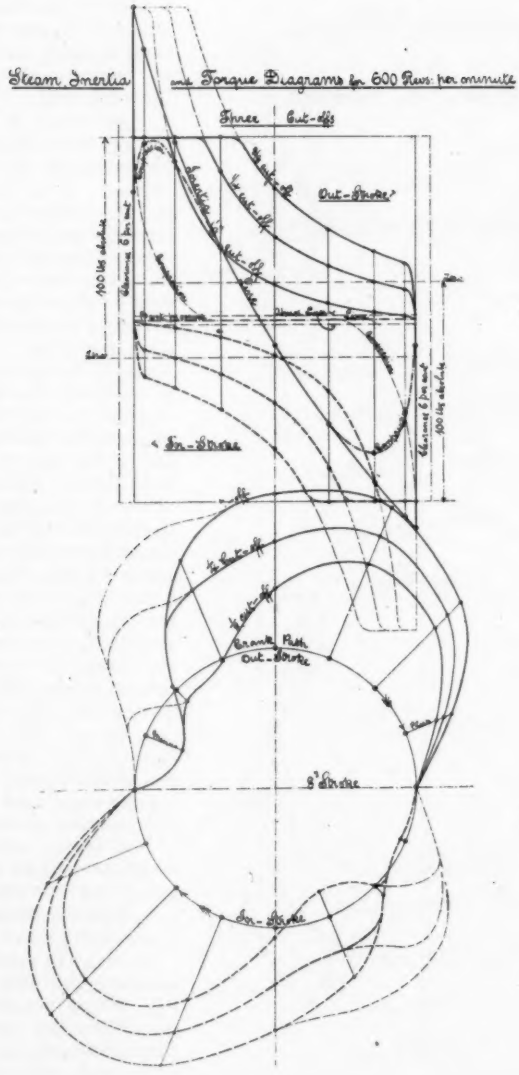
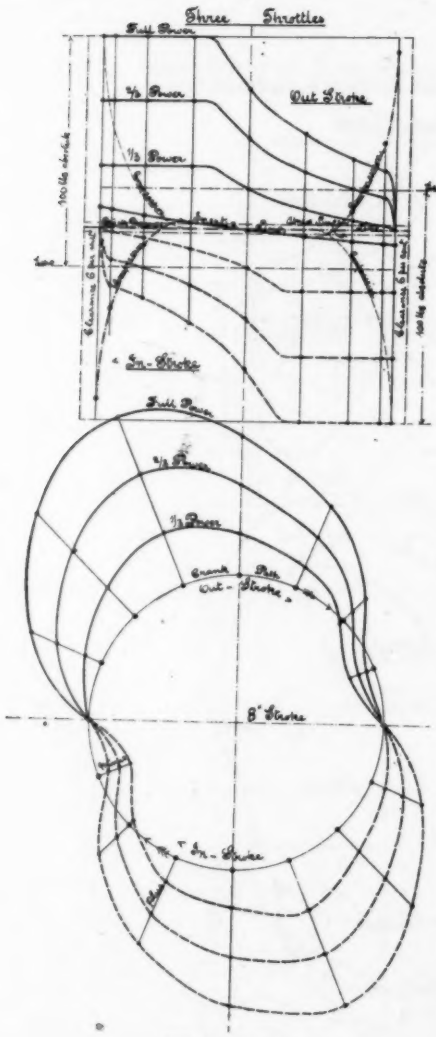

Steam Inertia and Torque Diagrams for 600 Revs. per minute
Three Cut-offs
Out-Stroke
In-Stroke
Crank Path
Out-Stroke
In-Stroke

FIG. 7.

FIG. 8



FIGS. 9 AND 10.

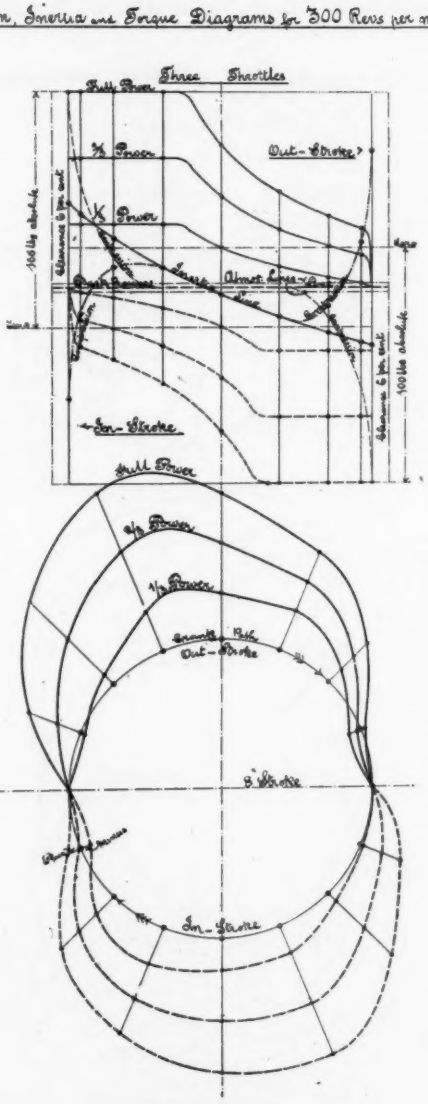
that, like Nos 1 and 2, they show too much tangential pressure on the crank in the early part of the stroke, and that a still higher speed would have a better effect, by decreasing the tangential force in the early part and increasing it in the latter part of the stroke. In all these figures a proportionate uniformity of effect is shown after the respective cut-off points.

Figs. 5 and 6 are constructed for 450 revolutions, and the improvement in the turning is very marked. It is quite clear that at the late cut-off in this figure the relative proportions of weight, speed, pressure, and compression are about correct; and, if carried into practice by such provisions as would ensure the form of the diagrams, would ensure very good results in the running of an engine. If anything, the speed would be slightly too fast, as there is no minus effect on the crank at the end of the in-stroke, except a very little quite at the end, in the case of the early cut-off. On the out-stroke there is just about enough minus to change the sides of the rod-eye quietly before the initial steam time. In these diagrams the compression is useful in preventing the excessive bulging of the curves at the ends of the strokes, in addition to its good and economical effects in the cylinder clearances. As in the earlier figures, it is evident, on inspection of the curves, that half-stroke cut-off would give a still further improvement in the turning, but in the matter of exhaust steam would be wasteful. A very early cut-off, on the other hand, gives only indifferent turning, especially in the early part of the stroke.

In order to carry the comparisons of speed effects still further, Figs. 7 and 8 are made for 600 revolutions per minute, all other particulars being the same as in the earlier Figs. The tangential force diagrams in Fig. 8 are curious. The height and depth of the inertia line, it is seen, have increased enormously, being of course 16 times higher than for 150

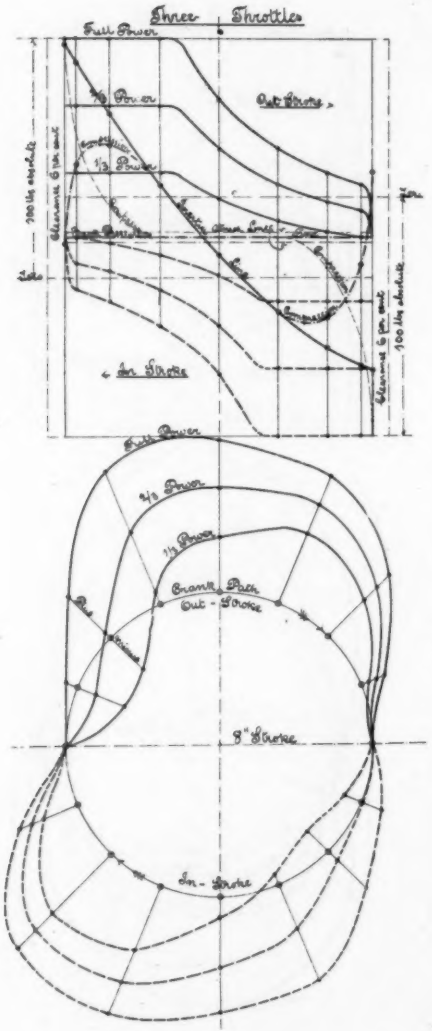
revolutions. In both out- and in-strokes the initial steam-pressure is far from being sufficient to balance the inertia of the piston line, which, at the commencement of the out-stroke, is equal to 142 lbs. pressure per sq. in. of piston, while on the in-stroke it is equal to about 95 lbs. per sq. in. of piston.

At the commencement of both strokes the crank would have to start the piston line, and the pressure would not catch up until after the second eighth of the semi-revolution. If there was any clearance at all in the eye of a connecting-rod working under such conditions, a bad double knock, at the commencement of the strokes and where the steam catches up, would be inevitable, especially on the out-stroke. The in-stroke forces of pressure and inertia nearly balance during the first two eighths in all the three curves; but from that point there is a curious divergence; the early cut-off minus effect being very bad in a very bad place, in the third and fourth eighths. The other two cut-offs are fair from the time they get out of the crank circle and become plus forces, and after the cut-off times are quite regular as in the other cases. A good result with such a speed would require the expansion curves of the steam diagrams carrying up to the height or pressure represented by the inertia line at the commencement of the out-stroke, which would improve the tangential force lines in the early part of the stroke without increasing the steam pressure at the end of the stroke, as shown by the corresponding dotted lines in the steam and tangential force lines of the two figures 7 and 8.



FIGS. 11 AND 12.

The second set of four double figures (Nos. 9 and 10, 11 and 12, 13 and 14, 15 and 16) are to show the differences of



FIGS. 13 AND 14.

effect in throttle governing to that of cut-off, which has been dealt with in the first set. All the speeds and other particulars, except the throttled pressures, are the same as in the former cases.

Comparing the respective pairs at 150 revolutions, it is seen that the differences of effect occur in the first halves of the stroke, the second halves being practically similar. In both cases the steam pressures are sufficient to form a positive force in the early part of the strokes, but there is a too considerable negative effect in the latter part of the same.

The corresponding pair at 300 revolutions shows a distinct advantage to the cut-off diagrams; for all cut-offs give a positive effect in the early part of the strokes, while the $\frac{1}{3}$-power throttle is negative for about one-sixth of the semi-revolution. The compression effect at the end of the strokes is considerably less than in the preceding examples, but still too much. The latter portions of the strokes are still similar. The collective higher work average of the cut-off diagram can easily be seen without measurement, though the weight of steam would be the same.

The pair at 450 revolutions show a still greater advantage to the cut-off diagram, the throttled figures being inadmissibly bad in the first halves of the strokes, especially the out-stroke. In this, both the $\frac{2}{3}$-power and the $\frac{1}{3}$-power lines are negative for nearly three-eighths of the time of the out-stroke, the full power being, of course, the same as in the cut-off diagram. The cut-off diagram shows a very good general result, as before stated. In this pair the difference

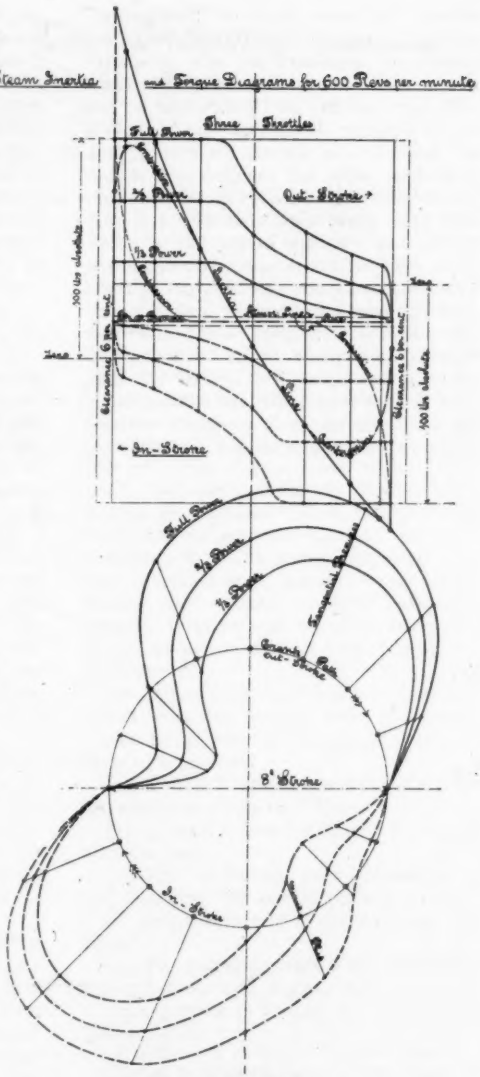
in the work areas is very pronounced.

The pair at 600 revolutions are both remarkable in form, and neither is good; but here, again, the cut-off has a considerable superiority over the throttle system. Neither of the diagrams is sufficient for the speed in regard to the steam pressure, and the limit of speed for the pressure in all these examples is clearly 450 revolutions; 600 revolutions would require 140 lbs. steam.

The distinct superiority of cut-off governing in the matter of torque, at all speeds which can in any way be termed high, is clearly indisputable.

No engine in the action of which the steam, or steam effect, comes on after the commencement of the stroke can by any closeness of adjustment of the connecting-rod brasses be made to run without knock, or at the best a dull, heavy thud. If there is any clearance in the brasses a bad knock will come on immediately after the commencement of the stroke, and also when the torque radials cross the crank path (*see* Diagrams). If the brasses are quite close, which is a generally impracticable condition, a thud or dull shock will be the result. Nothing can alter this in any engine in which the inertia of the piston line is greater than the initial steam-pressure.

Before leaving the subject of cut-off *versus* throttle as systems of governing, it may be useful to draw attention to the graphic illustration of the relative work economies which the diagrams afford. All the steam weights of the two sets of figures are relatively the same, but the mean production of work shown by the cut-off radials amounts to about 2,490 ft.-lbs. per stroke against 2,160 ft.-lbs. for those of the throttle. This is a difference of about 12½ per cent., and although something out of this advantage would be lost in the cut-off system by its greater range of cylinder temperature it is certain that there would still be a considerable advantage in its use.



FIGS. 15 AND 16.

Such graphic investigations as are here

shown, in these days of "strenuous" action in engines as in other things, are absolutely necessary to the practical-commercial steam engineer who deals with high speeds; as by their use he can see at a glance just about what his results will be before he spends his money, and, moreover, what his margins and consequent risks are. In days of slow motions and easy work, high coal-bills and easy profits, many things in the way of guess-work were often of no special consequence, providing the guess was high enough and nothing gave way; but the general necessity of high efficiency and immediate success consequent on the keen competition of late times has altered all that. The limit of possibilities has to be attained by such preliminary investigation without much experimenting, and, it is needless to say, is both more expeditious, certain, and cheaper than even the most ingenious "muddling through." For the production of anything like certainty and economy in results when dealing with extreme speeds, innate cleverness—which has hitherto produced most things which have been done in steam-engine work—is no longer sufficient without a backing of some such proof of the mathematical processes involved in the solution of the complication of effects which results from the action of engines of this class; and it needs no argument to show that the neglect of such simple precautions involves much risk.

A few figures illustrating compound governing and the consequent torque effects will be contributed later, after which high-speed governors and governing will be dealt with.

(To be continued.)

H. H. Dales

Machinery in the Tea Industry.

By H. J. KERSTING GREEN.

(Continued from page 44.)

ALTHOUGH the previous instalment of this series dealt with rolling and rolling machines, when the fermentation process is commenced we do not presume to have left the rollers; on the contrary, these machines continue to play a part of great importance, the processes of rolling and fermenting continuing simultaneously until a further stage is reached.

The term fermentation—although the one most generally in use—has been held by many to be incorrect, and abandoned by them in favour of the terms oxidisation or colouring. Twenty-three years back the columns of the *Indian Tea Gazette*—now the *Indian Planters Gazette*—contained a series of articles and notes on tea manufacture, which were added to and subsequently published in the "Tea Cyclopædia, Calcutta, 1882." A lengthy but interesting correspondence, which also appeared in the *Gazette*, arose out of these articles, to which reference will be made a little later on.

Machinery had at that time begun to play only a minor part in tea making, so that the opinions offered by contributors to the *Tea Gazette* were mostly based on experience gained in hand manufacture, by which only comparatively small quantities of *Mal* or rolled leaf were dealt with at a time.

The leaf in passing through the rolling stage, which was generally confined to one operation only, was pressed together into inverted cup-shaped balls of a size which enabled them to be conveniently grasped in the two hands, and allowed to remain until each successive portion was considered to have acquired the requisite stage of fermentation preparatory to the fixing by drying or firing. A very strong point was made of keeping the leaf pressed together in the shape described, owing to a prevalent idea that, if the balls were opened out, the leaf would gradually open out as well and lose the close twist imparted to it in the course of rolling. Further, that while pressed together, as mentioned, fermentation was held to be more rapid and even than if the balls were opened out. No hard and fast limit as to the length of time absolutely necessary to secure the correct stage of fermentation or colouring was imposed, this being left to the discretion of the manager or assistant of the estate, or the tea-house sirdar (foreman); although, under favourable conditions of leaf and wither, two to three hours was considered sufficient. In well-organised factories, where perpetual care and attention was bestowed on manufacture, the system produced excellent results; but, as will be seen later, the march of progress soon rendered it impracticable.

An extract from the "Tea Cyclopædia," which may be quoted with advantage, places the process of fermentation practically in a nutshell.

(1) Rolling fractures and smashes up the skeletons of the leaf fibre.

(2) These are thus brought into contact with the sap.

(3) The skeletons are composed of cellulose and the sap of acids and alkaloids, and the former is dissolved by the latter.

(4) The cellulose takes water from the sap and forms with it glucose.

Or, expressed in formula:—

Fermentation—

$C_6H_{10}O_5 + H_2O = C_6H_{12}O_6$

Cellulose + water = glucose or grape sugar.

$C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$.

1 of glucose = 2 of alcohol + 2 of carbon dioxide.

The knotty point around which the above-mentioned controversy raged appears to have been the presence of alcohol, upon which depended the fitness of the

terms fermentation, oxidisation or colouring. If the former were to be allowed to obtain, it implied that a certain stage of decay must have been reached.

It may, however, be noted that no one particularly cared whether fermentation, as expressed by the above formula, really took place, so long as the broker's reports on the invoice musters bore opposite the item *Infused Leaf* the gratifying words "bright, good colour"; and, perhaps, at the present moment this indifference is not wholly absent.

The introduction of machinery for rolling purposes was not at the first an unmixed blessing, at any rate in as far as the conjunctive fermenting stage was concerned; because with power it was at once accepted that a much coarser plucking of the green leaf, and in much larger quantities at a time, could be tackled than by manual labour; the amount of leaf making up each fill of the machine being anything between 80 and 160 lbs., representing as much as two to four able-bodied coolies could deal with in a day.

The system of doing up the *Mal* into the cup-shaped forms was abandoned, the successive fills of the machine being turned out into heaps of no very methodical pattern and covered with split bamboo or rattan mats to undergo fermentation. Results were not uniformly bad, but it may be safely inferred that, with a temperature of 96° to 100° F. in the shade, local heat must have generated in those masses to an extent sufficient to cause the decay necessary to set up fermentation and, in consequence, to produce alcohol.

It is not unfair to assume that both the correspondents to the *Gazette* were correct in what they offered for guidance, as in the one case, with fine leaf, a perfect wither, hand rolling, careful watching afterwards, and putting on the fires as nearly as possible at the exact moment, the stage did not get beyond oxidisation or colouring—that is to say, the glucose was not split up; on the other hand, with a coarser leaf, under or over withered, rougher treatment in the roller, and the subsequent method of heaping the *Mal*, tended to the formation of alcohol due to heat generated, and as a consequence fermentation.

Many of those interested in tea who may peruse these notes will remember in the early 'eighties that reports on musters were more often seen to contain the words "dull and uneven" in place of "bright, good colour" opposite *Infused Leaf*. In 1884 a pamphlet was circulated throughout the tea districts by Mr. Brownlow, a Chittagong planter, giving details of some experiments and useful hints, the chief item being the description of a form of tray he had recently been using for spreading the *Mal*. It consisted, briefly, of a framework 6 ft. by 3 ft., or any handy size, by a depth of 2 ins., the bottom having a network of coarse mesh, split bamboo or cane, stretched along and across and secured by thin strips of wood or bamboo nailed to the bottom of the framework, and the whole mounted on four legs, each about 6 ins. long by 3 ins. square. The mesh he covered with a damp cloth, on to which was spread about 2 ins. of roll, which in turn was covered with another damp cloth; the trays were then placed one above the other.

Mr. Brownlow appears to have been the first practical authority to abandon the term fermentation; for he is careful to mention that colouring would be accomplished in one to three hours, according to quality of leaf, state of wither, and time occupied in rolling. The 6-in. air-space between the trays and the damp cloths all tended to keep the leaf cool; and, added to this, Mr. Brownlow recommended a thatched roof building to be reserved exclusively for spreading and stacking the trays, and kept at as low a temperature as possible.

Although there were a few who ridiculed Mr. Brownlow's disinterested efforts, his system had in twelve months become an institution practically throughout the tea districts.

An alternative to the Brownlow system may be referred to, which consisted in spreading out the *Mal* about 1½ in. or 2 ins. thick, on a brick floor with a smooth surface, which had previously been well wetted and swept nearly dry, and covering the *Mal* over with a damp cloth. The points in favour of either were found to

be convenience, the output being practically the same in both cases.

It will be remembered that the state of wither has been mentioned as playing a part of no small importance in the subsequent fermenting or colouring process; and although the trays introduced had wrought a very decided change for the better, yet with coarse leaf and indifferent wither there still remained an uneven appearance in the infused leaf, which the trays did not entirely overcome.

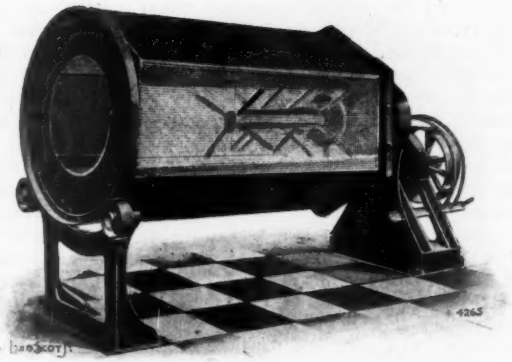


FIG. 41.—JACKSON'S ROLLED LEAF BALL-BREAKING MACHINE.

Subsequently breaking up the spell into two or three distinct operations, and allowing the leaf to cool on the trays, became a practice; while further advances were made in the shape of sorting the leaf after the first rolling stage, and allowing the finer grades to be dried when ready. The coarser kinds went through a further rolling, the operation being repeated; and instead of keeping the leaf pressed up together, every inducement was given to allow it to open and expose it to the atmosphere and cooling element.

Between 1875 and 1885, an attempt was made in the direction of obtaining a tea manufactured by a method which was partly Chinese and partly Indian. The tea plant in India and China is unquestionably one and the same; but while in India the grades are fixed by sorting after the mass has been made into tea, in China each grade is plucked and made separately and the fermentation stage is never reached; in fact, it is doubtful whether in some of the kinds the starch or gum stage is passed.

The Namuna (*anglicè*, "sample") tea sent down by Mr. Boyle of the Brahmapootra Company, in Assam, and others, possessing some very fine qualities, was manufactured on pretty much the same lines as described by Mr. C. A. Bruce—when issuing one of his reports on progress to the East India Company in the 'thirties, his entire tea-house system being under the supervision of imported Chinese tea makers—with fairly fine leaf, a moderate wither, and the panning process. Into a circular shallow pan, resting on a brickwork stove, a quantity of leaf was placed and kept in motion by the hands. As soon as the requisite softness had been

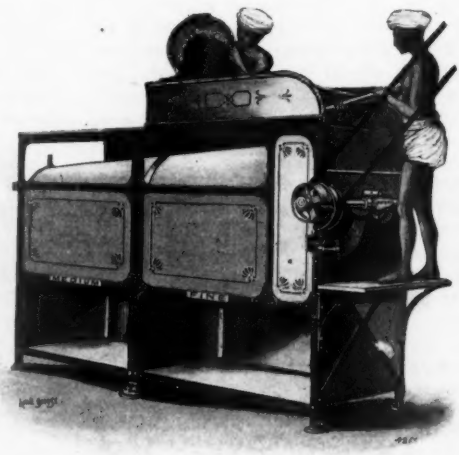


FIG. 42.—DAVIDSON'S PATENT ROLL-BREAKER, COOLER, AND SORTER.

acquired by the contents they were taken to the rolling machine and were, in turn, again put through the panning process and a further rolling, the fermentation stage being longer or shorter as was deemed necessary. With a much lighter wither, scarcely enough rolling to twist the leaves, and no fermentation, the result would have been Green tea in place of Black.

These teas were well reported on, but the system did not obtain, probably because the panning process was too tedious and, consequently, too expensive.

Information is to hand that, in view of a possible demand for Green tea, Ceylon planters are turning their attention in this direction; but the same objection to the panning process, as originally adopted, will no doubt be found as apparent now as twenty years ago. If, however, a demand for Green tea should become an established fact, it seems to us there are great possibilities of a probable and near future for Mr. S. C. Davidson's Green Leaf Witherer, modified no doubt from his 1894 pattern. The original machine Mr. Davidson was not satisfied with, because in its action it followed somewhat too closely the process of panning.

The machinery employed in the oxidising or colouring process—it may be as well now to abandon the term fermentation, as it is now extinct—is not very extensive.

When the practice of sorting the leaf between and after the rolling stages became popular, machines of a simple character were improvised on the factory; and, later on, improved upon by Mr. William Jackson and others.

Mr. Jackson's Rolled Leaf Ball-Breaking Machine, Fig. 41, is designed for the purpose of breaking up or disentangling the inter-woven lumps or balls of leaf created during the rolling; and if the leaf is passed through this machine immediately it is discharged from the rollers, it is at once cooled down to its normal temperature.

The leaf is fed into the circular mouth of the revolving inclined screen; and as it passes through this the smaller tea escapes through the ½-in. mesh wire, and the lumps or balls are dropped on to the pronged beater placed centrally on the screen, to which a high speed is given, the lumps or balls thereby being completely broken up and the leaf ventilated and cooled down.

Mr. Davidson's improvement in this direction is shown in Fig. 42.

This machine does not differ very widely from the Jackson's, the principal advantage attaching to them both being

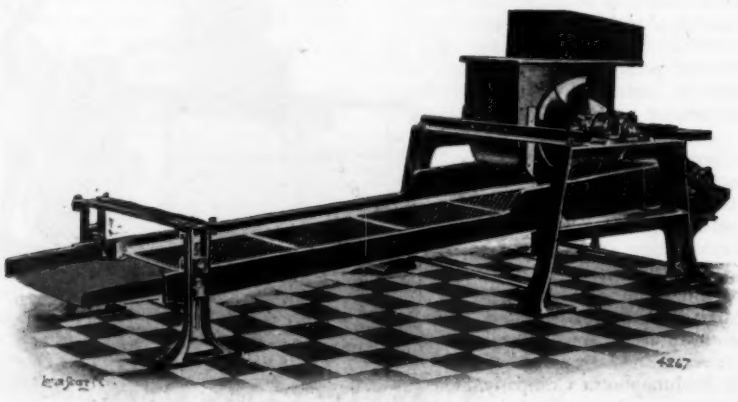


FIG. 43.—THE "MORELAND" ROLLED LEAF SEPARATOR, AËRATOR AND SIFTER COMBINED.

their simplicity. Mr. Davidson's machine, as will be seen, is entirely self-contained; but either one or the other might be selected, as best suited to the factory circumstances. The principle of both these machines is based on the lines laid down by the users of improvised machines; and although the latter did their work quite well something of a more substantial character was readily welcomed, as factory-built machines are never very successful or economical in the long run.

A machine of a somewhat different type was introduced by Mr. Nathan Sharpe, later on called the "Moreland" Rolled Leaf Separator, Aërator and Sifter combined. (Fig. 43.)

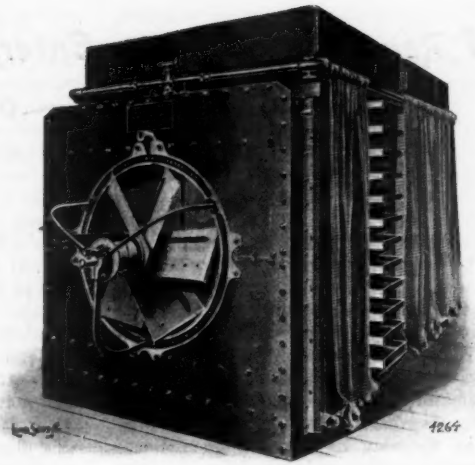


FIG. 44.—NATHAN SHARPE'S PATENT "SIMPLEX" COOL OXIDISER.

The "Moreland" improved pattern machine is based on different lines from the two previously described. Attached to the chamber into which the leaf is first placed is a fan for cooling and aërating the leaf, while the sifting process is accomplished on an inclined plane capable of being readily raised or lowered to suit circumstances.

The process of cooling and breaking up the balls of *Mal* is not, after all, one calling for any display of great mechanical genius; so that, while there are on the market other machines for the purpose, any one of the three described may be relied upon to effectually accomplish what is claimed for it, and the choice might as well be based on the lowest first cost as anything else.

Mention may be here made of Nathan Sharpe's Patent "Simplex" Cool Oxidiser. Introduced some four or five years ago, the advantages claimed are numerous. It has a leaf surface of 864 sq. ft., requires 1½ h.p., consumes two gallons of water per hour, and oxidises the *Mal* at an even temperature and regular time throughout. (Fig. 44.)

Information is not to hand as to how large a measure of success the apparatus has realised. Reference to the illustration will at once reveal its action, and the idea appeals as one which is theoretically and practically correct. A long description appeared in the *Home and Colonial Mail* of August 27th, 1897, which those interested may find worthy a perusal.

The writer is indebted to Mr. Maguire, of Messrs. Davidson & Co., Ltd., for particulars of an experiment made in colouring, which may be very briefly described. Trays of the Brownlow pattern are used in a thatched-roof building, in which every effort is made to keep the interior as cool possible by means of an exhaust fan of just sufficient power to impart motion to the air inside. The wall of the building opposite the fan consists of lattice-work, covered with one or two thicknesses of coarse jute cloth, kept constantly wet, the air drawn through it by the fan being cooled in its passage. Due regard must be paid to the quality of leaf, state of wither, and length of time occupied in rolling, when fixing on the duration of this process.

H. H. Kerslake Green

A Record of British Enterprise on the Continent.

By E. C. AMOS, M.I.Mech.E.

It is well known that until recent years this country was the workshop of the world, and as a natural consequence secured most of the contracts for big engineering installations on the Continent of Europe and abroad generally. Not only were the contracts carried through satisfactorily both to our foreign clients and ourselves, but very little was done by us in the way of advertising ourselves beyond the effects produced by the good work we had done. It is true that competition was not nearly so keen then as now, and consequently there was less need for us to enlarge upon the importance of our work. All this has now changed as a result of other countries competing with us in the very work of which we held almost a monopoly. But not only have we now to face serious competition, but our competitors, and especially those in the United States, have made it a part of their business to make widely known what they have done, and what they can do—in other words, to largely advertise "their wares." That being the trend of the new order of things in engineering commerce to-day, it is necessary and also encouraging to be able to record instances where Great Britain has been able to hold her own against foreign competition. The case in point is in respect to a recent contract placed by the Corporation of Amsterdam for a number of hydraulic travelling wharf cranes, hydraulic lifts, accumulators, etc., for the new Entrepôt Docks at Amsterdam. This contract was competed for by British, German, French, and even Dutch firms, and the order for the whole contract (excepting the pumps, which were electrically driven, and were supplied by the Westinghouse Company) was secured by Mr. Robert Middleton, M.I.Mech.E., of Leeds, this firm's tender being the lowest offered by any English firm competing. It was, however, higher than some of the foreign tenders, indicating that British reputation is still able to secure for itself a preference. Before describing this installation, it is pleasing to state that the whole contract has been carried out to the entire satisfaction of the Amsterdam authorities, and the machinery has been in constant work since its completion some months ago, when the docks were opened in state by the young Queen of Holland, who, together with her suite, ascended to the top of the new building erected on the docks by means of the hydraulic lifts referred to. The time taken to complete the contract was fifteen months, and considering the magnitude of the work this is a very creditable performance.

For the purposes of description, it will be convenient to divide the subject under several headings.

Accumulator.

Fig. 1 is taken from a photograph of the accumulator tower and pumping station, in which the tall building on the left contains the accumulator. With the power-house we are not concerned in this article, as the power-station formed the subject of another contract, but of the accumulator we are able to show a sectional view and plan. (See Figs. 2 and 3.)

The accumulator is 18 ins. diameter by 22 ft. stroke, having a wrought-iron weight-case 9 ft. 9 ins. diameter by 22 ft. 6 ins. high; the cylinder and ram are of cast iron, and the top crosshead for carrying the weight-case is built up of steel plates. The weight-case is loaded to give a pressure of 750 lbs. per sq. in., requiring a gross load of 80 tons. As seen, the accumulator is placed in a strong wooden

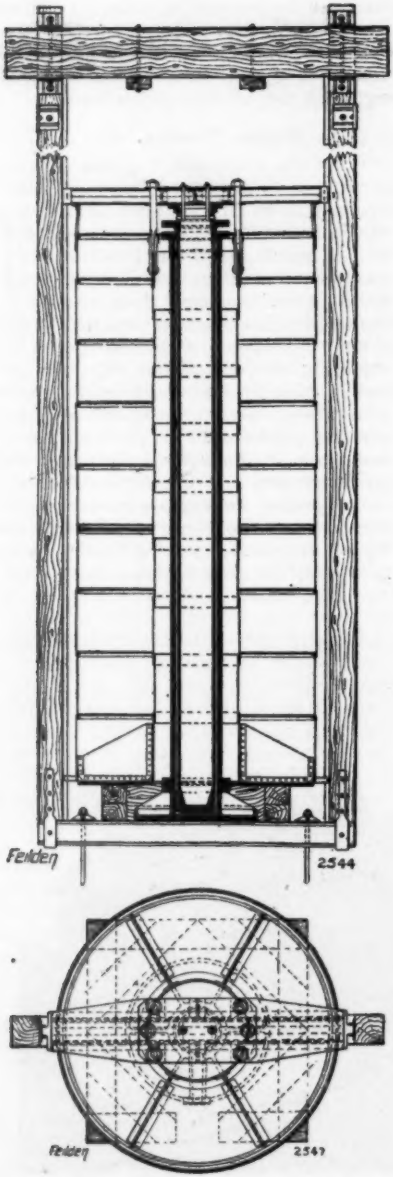
framework which, besides forming guides for the casing, also acts as a stop should the pumps overrun. These are controlled from the accumulator by an automatic switch (not shown), which comes into action when the accumulator reaches its full stroke. Should both these safeguards fail, another is provided in the shape of a valve, the lever of which is attached to the crosshead by a chain, so that it is bound to open when the accumulator ascends above a certain point, and thus let the water escape. The accumulator is also provided with a special automatic speed-regulating valve, which can be so arranged that the accumulator cannot descend faster than a given speed from any cause whatever. Thus, should a pipe burst in any of the mains, or any sudden call for a large amount of water take place, the accumulator could not descend rapidly upon its stops and so injure itself.

The efficiency of the valve was several times proved, as, owing to the very soft nature of the ground and some unsatisfactory piling on the part of another contractor, several of the pressure pipes were at various times broken, thus allowing a free escape of the water. In every case, however, the descent of the accumulator was perfectly regulated, and all damage prevented.

Mains, Valves, etc.

From the accumulator a line of 5-in. pressure-pipes is taken into a main junction box, in which are placed all the stop valves, both pressure and return. A line of 5-in. pipes goes from this box to the quay side of the warehouse, and is continued 5 ins. diameter along the whole front. Another line, 4 ins. diameter, runs along the land side of the warehouses for supplying the lifts. These two lines are connected at the end of the building by a 3-in. main. Return mains are in every case laid parallel with the pressure mains, and are 1 in. diameter larger than the pressure mains. Owing to the soft nature of the ground these pipes are carried on piles, placed about every 15 ft., and are buried in trenches varying from 3 ft. to 5 ft. deep to protect them from frost.

FIG. 1.—POWER AND ACCUMULATOR BUILDINGS.



FIGS. 2 AND 3.
PLAN AND ELEVATION OF ACCUMULATOR.

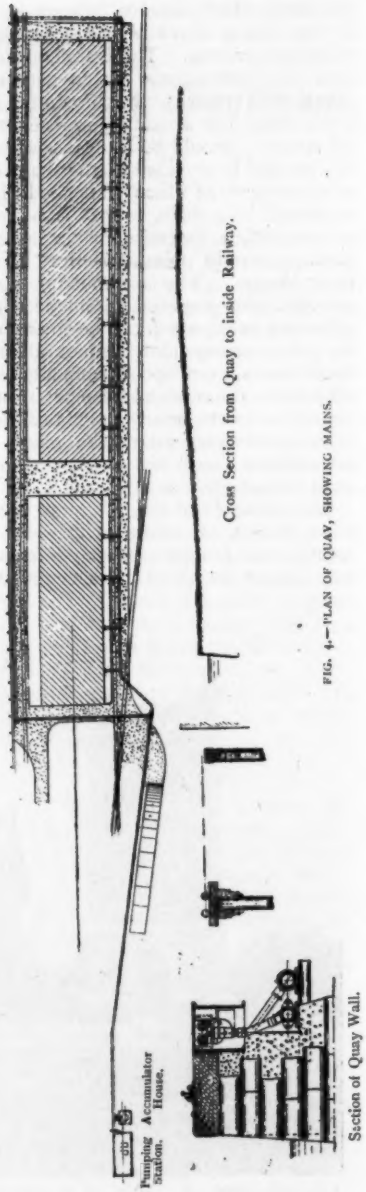


FIG. 4.—PLAN OF QUAY, SHOWING MAINS.

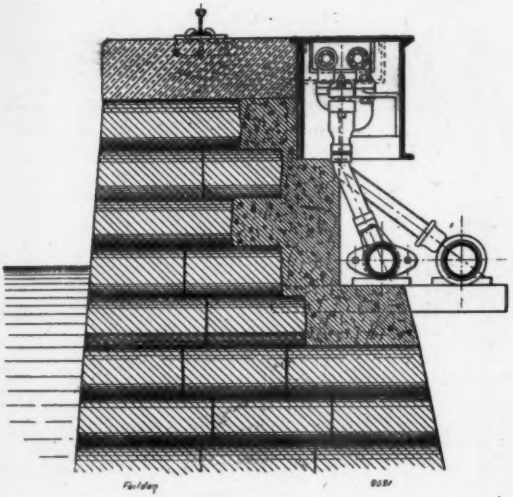


FIG. 5.—SECTION OF QUAY WALL, SHOWING HYDRANT BOXES AND PRESSURE AND RETURN MAINS.

Also just outside the main valve-box there is placed in the 5-in. pressure main a large double-bend expansion pipe of solid drawn copper, to take up any variation which may occur in the loose ground. At the end of the 4-in. line there is also placed a spring-loaded relief-valve, to take any shock which may happen to come upon the pipes. The total weight of the pressure pipes is 80 tons, and of the return pipe 43 tons. Along the quay side are placed 21 hydrant boxes (*see* enlarged Section of Quay Wall, Fig. 5), connected to the mains by 2-in. pressure and 3-in. return piping, and fitted with stop-cocks and coupling pieces to attach to the sliding pipes of the cranes. A trench formed by a creosoted oak box, bound together with iron knees, and covered with chequer plates, runs between these boxes, and forms a safe place for the sliding pipes when the crane is some distance from a hydrant.

These sliding pipes are explained in detail under the heading of Cranes.

In order to satisfy the requirements of the Corporation's engineer as to the strength and soundness of the piping and valves, the following severe test was made:—

The piping having been filled with water at the working pressure, the 5-in. main throughway valve, next the T-piece at the power station, was closed; also all the valves at the different machines (cranes and lifts) and those at the accumulators. A pressure pump was then attached at a convenient point in the pipe

FIG. 6. GENERAL VIEW OF WAREHOUSE, SHOWING LIFT TOWERS.

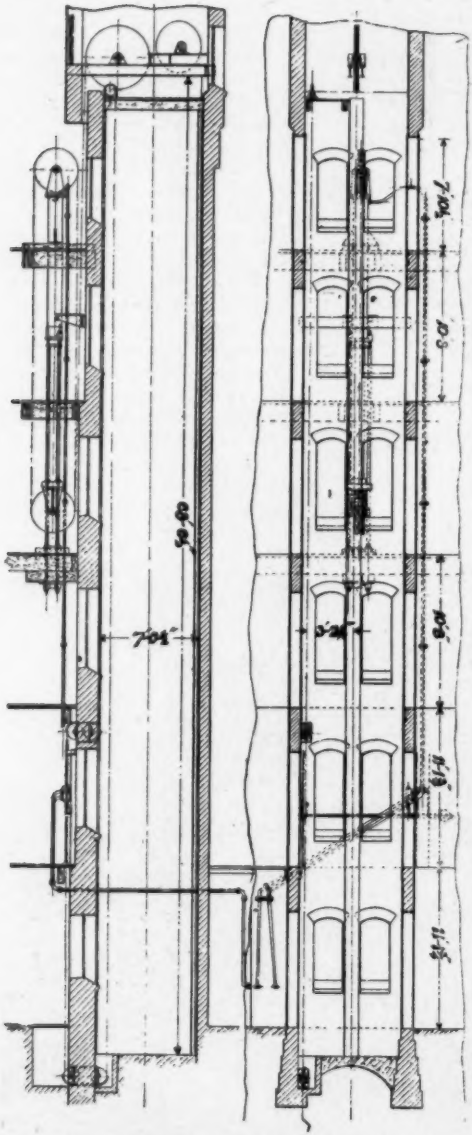


FIG. 7.—VERTICAL SECTION OF LIFT TOWER.

circuit, and a pressure of 1,100 lbs. per sq. in. was maintained for several hours, in order to determine if there was any leakage, and this was satisfactorily carried out.

Another requirement was that all cast-iron parts under water pressure should be cast vertically, and should stand a pressure of 1,500 lbs. per sq. in.

Lifts.

The lifts were 12 in number, and a view of the warehouse, showing some of the lift towers, is clearly shown in Fig. 6. Fig. 7 shows two vertical sections, taken through the lift towers, whilst Fig. 9 gives a horizontal section of the well, and Fig. 8 a plan of the top gear, and shows the rope pulleys for suspending the cage.

Fig. 10 shows front and side elevations of one of the cages, Fig. 11 being a plan of same.

Fig. 12 illustrates details of the lift cylinders and pulleys.

Fig. 13 is an enlarged detail of the special guides and brake pinion for the lifts: this is also seen in position in Fig. 10, and being of a new and interesting type further description is given later on.

Fig. 14 is a detail of pressure inlet for the lift cylinders. "Curran's" patent hydraulic slide valves are fitted to all the lifts. The principal feature in this valve is the means provided for lubrication. As is well known, the great difficulty with all valves (and especially hydraulic) working under high pressure is to secure proper lubrication between the surfaces. In the "Curran" valve this is secured by drilling a number of very small holes on the under or free side of the valve; these small holes communicate with a larger hole bored from the top of the valve, and into which holes are fitted small pistons. The space under the piston is filled with suitable lubricant, and the pressure of the water acting in the plunger forces the lubricant through the pin-holes upon the valve-face, and main-

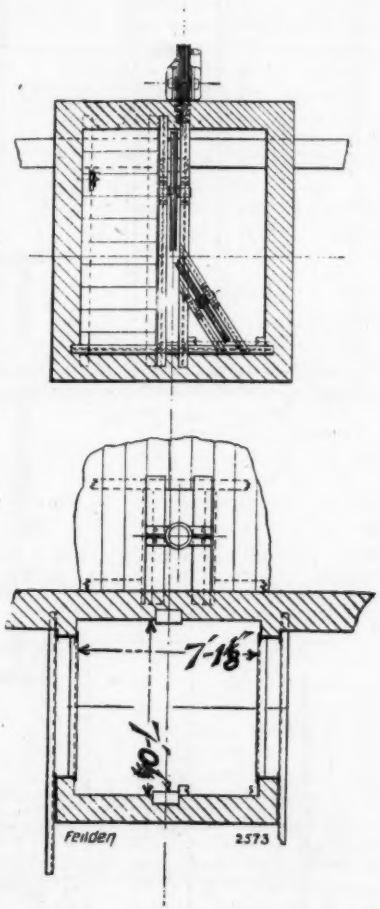
tains proper lubrication for at least three months' wear, even when the valves are in constant use; and reduces the friction by at least 50 per cent., thus making the use of a much larger value than is usually possible.

Referring now to the lift, and dealing first with the guides, these are of cast iron, carefully planned and provided with a toothed rack, into which gear the pinions of the safety apparatus already referred to and shown in Fig. 10. The guides are bolted to wooden posts fixed in the well towers. The sections of which the guides consist are faced on the end and carefully bolted together.

The cages shown in Figs. 10 and 11 are constructed of wrought iron and provided with strong wooden floors and tops. Under the bottom of each cage is fitted a strongly constructed bolt arrangement worked by a hand lever, by which the cage can be firmly fixed at the proper floor level at every story. Each cage is provided with two "Becker" patent centrifugal safety apparatus, the pinions of which run in the rack on the guides, as already stated.

The action of this apparatus is based upon the principle of a centrifugal governor. The pinion gearing into the toothed guide of the lift necessarily revolves as the cage ascends or descends, and in so doing actuates three pendulum arms held in position by springs, the whole revolving in the cast-iron box shown. These springs can be adjusted to suit the required speed of the lift, and should the lift from any cause exceed this speed they will be forced out by centrifugal force and form a friction contact with the sides of the box, thus tending to retard the speed of the pinion which gears into the toothed guide, and so preventing the cage from falling faster than any desired speed. One great advantage of this apparatus over the usual grip-and-wedge apparatus is the fact that, should anything go wrong with the hoist gearing, the cage will steadily descend to the bottom floor, instead of being held fast in what sometimes happens to be an inconvenient part of the well. By using this apparatus the maximum speed of the cage, even if all the ropes were to break, could never exceed 30 per cent. more than the normal.

It may be mentioned that this safety apparatus is very certain in its action, and the inventor usually tests it by remaining



FIGS. 8 AND 9.—PLAN OF TOP GEAR OF LIFT AND SECTION THROUGH WELL FOR LIFT

in the cage and descending with it after the ropes have been cut. The cages are partially held in equilibrium by counterweights, each hanging on two steel ropes,

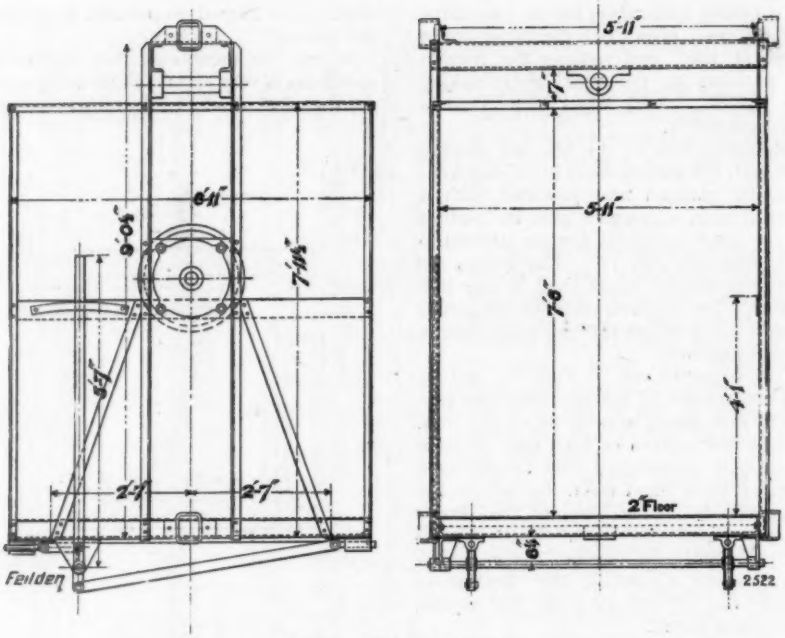


FIG. 10.—ELEVATIONS OF CAGE.

which pass over two pulleys, 4 ft. 9 ins. diameter, fixed at the top of the lift well, the other end of the ropes being, of course, attached to the cage itself. The lift cylinders, which are shown in position in Fig. 7, and in detail in Fig. 12, are provided with suitable feet, by means of which they are fastened in a vertical position to wooden posts placed on the inside of the warehouse wall. The flanges are placed beneath, so that the weight of the rams partially balances the cages. The ratio of power to load is 1 to 6, and there are three double-grooved pulleys mounted on the head of each ram, so that the cages may be connected with the cylinders by two steel ropes; on the end of each cylinder are two double-grooved sheaves, and above, in the lift-well, there are two pulleys, 4 ft. 9 ins. in diameter, over which run the hoisting ropes connected to the cage. The steel ropes have a breaking

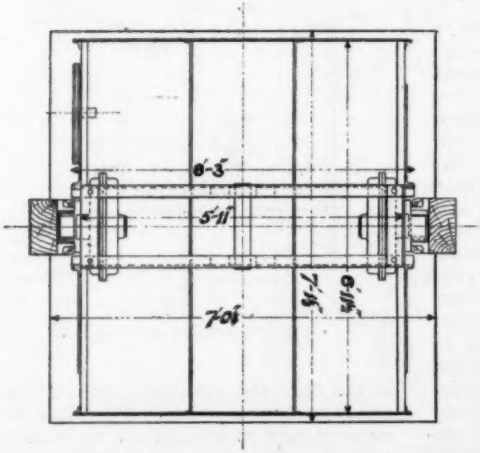


FIG. 11.—PLAN OF CAGE.

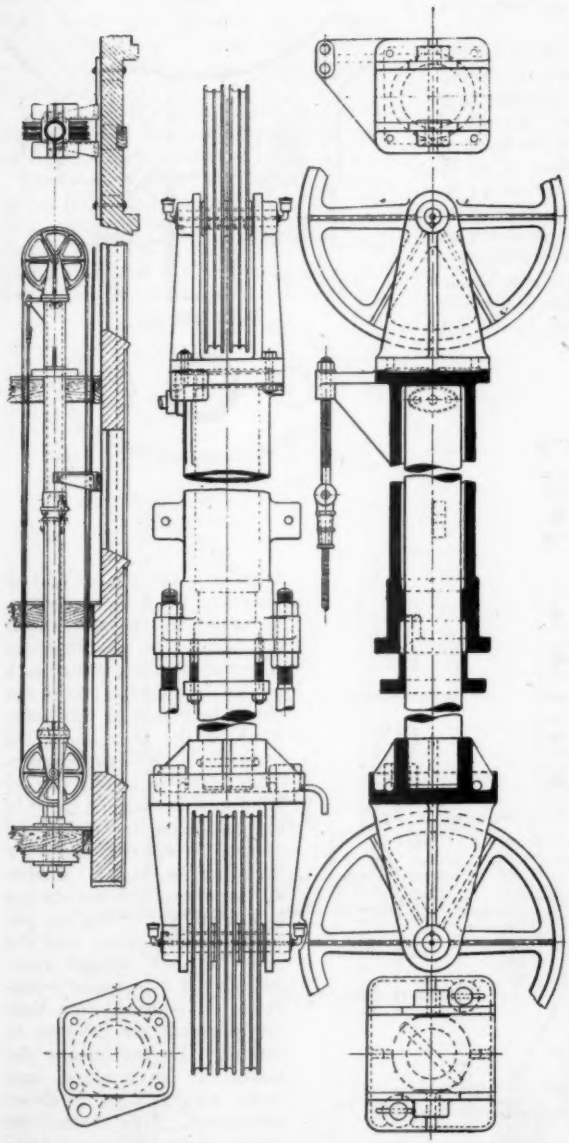


FIG. 12.—DETAILS OF LIFT CYLINDERS AND PULLEYS.

strain of 22 tons, and are attached to the cage beams at the top. The cross-head of the lifting plunger is guided on wrought-iron guides, stops being provided to automatically push over the starting lever, and thus shut off water supply, as is the usual practice. Each lift is capable of lifting a load of 30 cwts., and has a travel of 54 ft., the speed of lifting being 2 ft. 6 ins. per second. The diameters of the lifting rams are 8 ins., and the stroke 9 ft.

Cranes.

We now come to a description of the cranes, which possess some interesting features, and are seen in Figs. 15 and 16, in which the former is from a working drawing of one of them, while the latter shews the stability diagram. These are nine in number, and as they are all similar in construction it will sufficeto describe one of them.

As will be seen by reference to the illustrations, they are of the travelling wharf type, the gantry on which they are mounted having one long and one short leg, the former travelling in rails laid on the upper stones of the quay wall, and the latter, or short leg, in the warehouse gallery. Between both rails there is a difference in height of 11 ft. $5\frac{1}{2}$ ins., the gauge of rails, measured from centre to centre, being 25 ft. $11\frac{3}{8}$ ins. Each crane has a lifting capacity of $1\frac{1}{4}$ tons at a radius

of 42 ft. 4 ins., and a lifting height of 90 ft., of which 20 ft. extends below the quay wall.

The frames, jibs, and gantries of the cranes are chiefly constructed of riveted steel-plates, the hydraulic cylinders and rams being of best cast iron. As will be noted each crane is fitted with two hoisting powers, the one having a radius of 42 ft. 4 ins., and the other a radius of 21 ft. 7 ins., the load to be lifted at the shorter radius being 3 tons, or twice as much as that at the longer radius. The consumption of water is partly proportionate to the load, a result obtained by the adaptation of telescopic plungers working in the lift

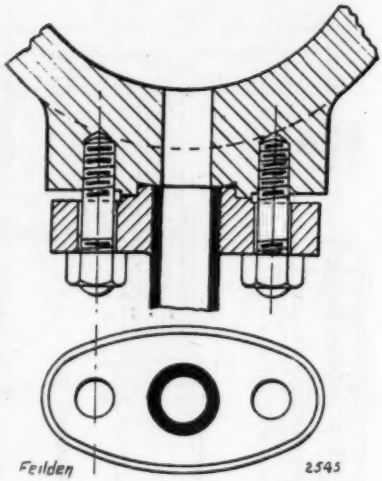


FIG. 14.—DETAILS OF PRESSURE INLET FOR LIFT CYLINDERS.

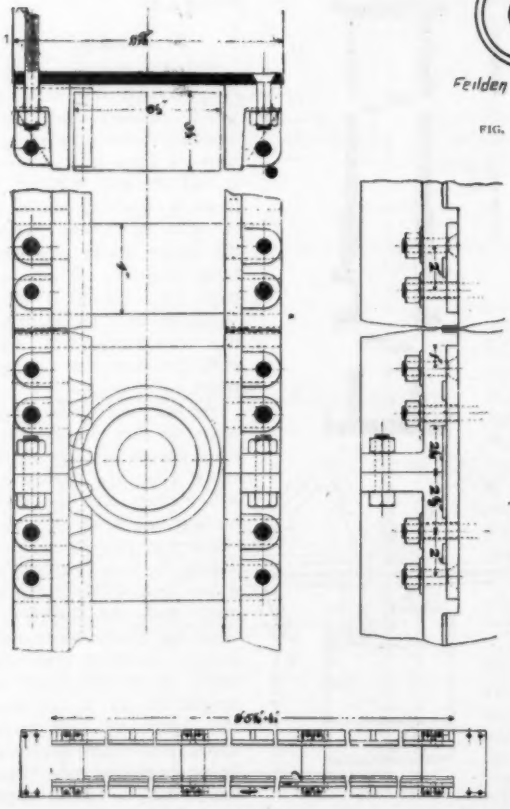


FIG. 13.—DETAILS OF GUIDES AND BRAKE PINION FOR LIFTS.

cylinder. On the middle of the crane jib a chain-sheave, or pulley, is applied. Over this sheave the hoisting chain is carried, a loose mantle-block looped in, and the end of the chain, by means of the hook, fixed to the shackle on the crane-jib. By this arrangement loads of 3 tons can be lifted and slewed in a circle of the smaller radius mentioned above. When the cranes are to work with the smaller lifting-power, the outer plunger is held down by latches put on the crane pillar, and the inner smaller plunger alone ascends; if the greater lifting-power is required, then both the plungers are allowed to ascend. By this means the power can be doubled, and larger weights lifted as above mentioned. The catches for holding down the outer plunger are put in and out of gear by a handle or crank, axles

and rods. The cranes are capable of lifting from 23 ft. below to 67 ft. above the upper stone of the quay wall, or 90 ft. in all, and are able to turn round in a arc of 370 degs.

The cranes are so constructed that no projecting part can come in contact with the rigging of ships lying at the quay.

The crane wagons consist of two carrying-beams placed immediately above the rails, wherein the cast-steel travelling wheels are fixed; at the ends of the beams are fixed the jack-screws for the discharging (or freeing) of the travelling

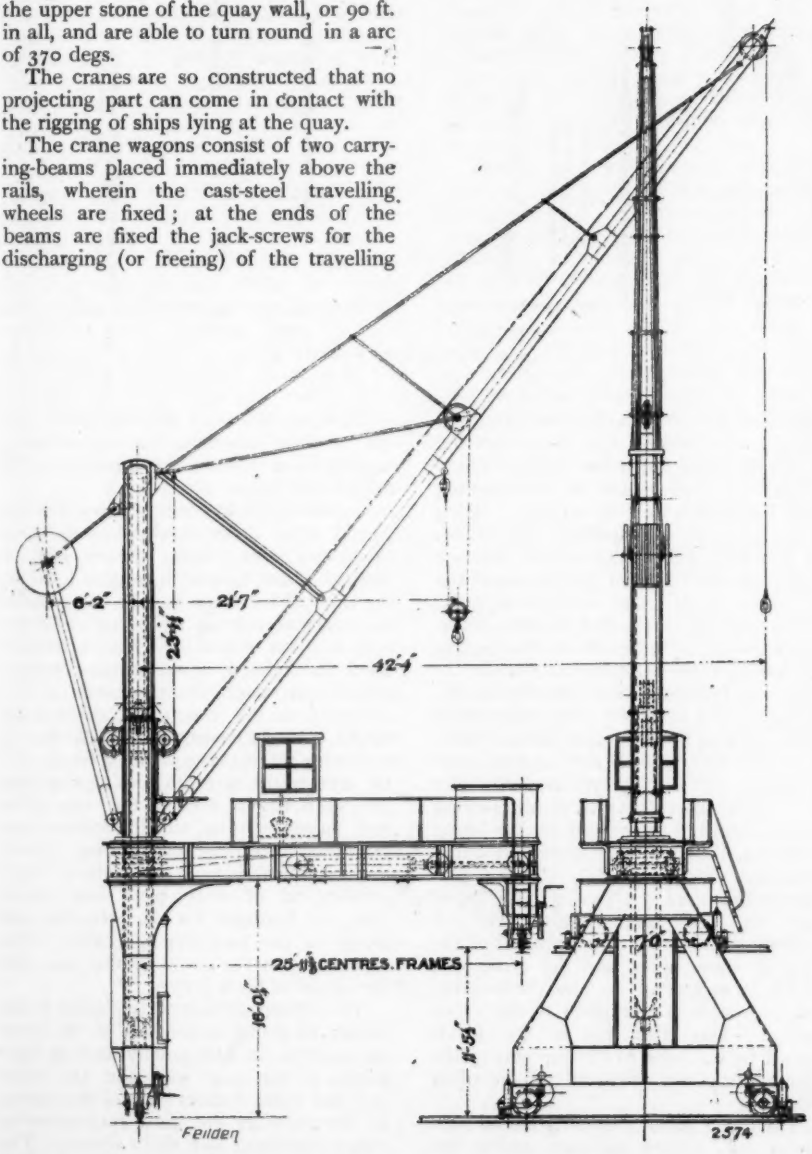


FIG. 15.—GENERAL ARRANGEMENT OF HYDRAULIC CRANES.

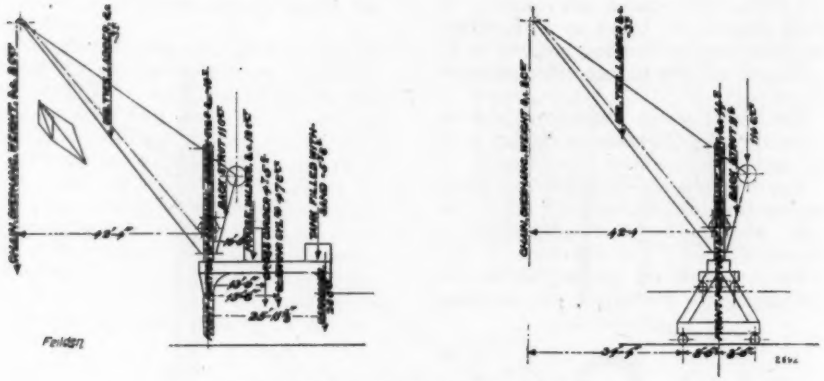


FIG. 16.—STABILITY DIAGRAM FOR HYDRAULIC CRANES.

wheels, and the clips for fastening the crane to the rails. On these carrying beams the crane wagons are built. These at the waterside consist of two slanting legs, between which is an oval casing wherein are the crane pillar and the tubes for the inlet and outlet of the pressure water. At the height of 4·95 m. above the top stone of the quay wall the legs and casings erected on the beams at the waterside and on the beam above the gallery are connected by a horizontal casing.

At the bottom of the framing on the waterside is a cast-steel plate with turned neck, in which the crane pillar works; there are also placed in the horizontal casing the two slewing cylinders with their accessories, the slide valve for the slewing motion, and the valve-chest for the lifting cylinders, the necessary inlet and outlet pipes for water, gas, etc. On the part above the gallery is placed a ballast tank with the necessary ballast. The revolving part of the crane consists of the vertical crane pillar and the crane jib, which is supported by the crane pillar just above the cover plate of the crane wagon. The other end of the jib is joined by tie bolts to the top part of the crane pillar, and balanced on the other side.

The crane pillar is constructed of steel plates and angles, between which the lifting cylinder is placed; at the bottom of the crane pillar is a cast-iron piece with hollow pivot, on which the whole turns, moving in a cast-steel toe-piece, which is fixed to the beam.

On the top of the centre lifting ram are placed three chain sheaves in a cast-iron crosshead with guides, which run in vertical slides formed by angles fixed to the sides of the crane pillars. The slides are closed at the top by a stop of double angles. Just above the point where the crane jib is fixed to the pillar, there are placed two chain sheaves, and on the other side of the crane pillar, at the same height, a single chain sheave. At the top of the jib also a chain pulley is fixed. At the level of the cast-iron turning-ring cast-iron segments are fixed to the crane pillar and lifting cylinder, which segments are machined to suit the turning ring. Above these segments is fixed the turning drum, constructed of steel plate and angle-iron, and arranged for the reception and fixing of the two turning chains. The ratio between the stroke of the rams and the height of lift is 1 to 6.

The slewing cylinders are placed in the horizontal casing at the top of the crane wagon, and lie horizontally and at right angles to the quay wall, and are firmly fastened to the bottom plate of the casing. In the cylinders are rams, each provided with a crosshead and chain sheave. The crossheads travel between slides fixed in

cast brackets. At the outsides of the lifting and slewing cylinders are fastenings for fixing the ends of the lifting and slewing chains. On the slewing cylinders an arrangement is placed consisting of a sliding bar with adjustable rings, levers, and rods to cut off, automatically, the pressure when the crane has moved through any required angle. The lifting chain at the load end has a hook with clipper, above which there is a pear-shaped weight heavy enough to bring down the empty chain.

The valve-chest for the inlet and outlet of the water to and from the lifting cylinder is constructed wholly of gunmetal, provided with plungers, seats, packing boxes, and relief valve. The plungers are held down by weighted levers, and the slide-valve for the inlet and outlet of the water to and from the slewing cylinders is also constructed wholly of gunmetal and provided with relief valve and necessary air and drain cocks. All turning and rubbing parts are provided with oiling arrangements and lubricators.

The spindles of the chain sheaves are fixed, bored along the axis, and at every sheave provided with a cross hole through the half thickness of the spindle, at one end the long hole is stopped, and at the other provided with a lubricator. The chain sheaves are all bushed with gunmetal.

Above, on the crane wagons, a wooden house is placed, provided with two glass doors and a sliding glass window, and affording protection against the weather. Into this house come the levers, by means of which the slide-valves for the slewing gear, and lifting cylinders are actuated. With every crane there are eight iron coupling-pipes with gunmetal couplings, two of them provided with a telescopic brass or copper pipe with packing box.

The horizontal casing in which the slewing cylinders, etc., are concealed, is provided on the top with hinged shutters, which are capable of being properly closed. Above the air and drain cocks, the weights of the lifting valve, and wherever necessary, handholes with round revolving covers are fitted. In the oval casing in which the lifting cylinder is concealed, in the vertical casing of the after leg, and in the projecting chest where the coupling pipes are enclosed, hinged and well-bolted doors are placed. Against the four-cornered vertical casing of the after leg an iron ladder is placed, and on the horizontal casing and on the jib suitable railings are fixed.

This completes the description of the plant as erected, and which is now in daily use.

We may also remark that the whole of this contract was erected entirely under English supervision; Mr. Middleton's foremen and superintendents being present from the commencement of erection to the final passing and acceptance of the machinery, though the whole of the labour was obtained locally.

Ewart & Amos

New Machinery. Appliances. Structures. & Processes.

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The New Generating Plants of the Niagara Falls Power Company.*

THE growth of the applications of the Niagara Falls power has been so rapid since the starting up of the first power-house in 1895 that the entire 50,000 h.p. of the first plant has been taken up to its limit. This growth was anticipated by the company three years ago, when the hydraulic development of a second plant was started under way. This plant is nearly completed, and within a few months the first generator of its equipment will be performing useful work.

This power-house, from a popular standpoint, may be considered a duplicate of the old one, with which every engineer is familiar, and differs only in some of its technical details. It is located on the opposite side of the in-take canal and nearer to the river, and has its water-wheels placed at the bottom of its own separate wheel-pit. Discharge water is led out from this pit by a branch tunnel, which, after leading independently for about 600 ft., joins the main tunnel, which has a capacity of 100,000 h.p. The new turbines are somewhat different from those in power-house No. 1, being of the internal discharge type, and having the discharge water carried off through draught tubes, which add about 10 per cent. to the effective head. This increase in efficiency gives 10 per cent. more power for the same amount of water used in power-house No. 1, and, in consequence, the plant is laid out for eleven units of 5,000 h.p. each, instead of ten. The turbines and governors were designed on the Continent, and were built in Philadelphia. The governors are of the oil-pump operated type, and give a maximum variation of speed of about 5 per cent., with 100 per cent. load variation, and for fractional changes in load the regulation obtained is about the same as that of a good steam-engine.

The electrical equipment in general has the same characteristics as the apparatus in power-house No. 1. The generators are of 5,000 h.p. each (3,750 kilo-watts), wound for 2,300 volts, two-phase, twenty-five cycles at 250 revolutions per minute. This type was decided upon on account of its exact interchangeability with power-house No. 1. It was considered that the advantages which might result from winding the new generators for a higher voltage would be more than offset by the lack of interchangeability between two power-houses located so near together as to be governed by the same conditions.

Electro-technically, power-house No. 2 differs in several essential details from the installation in the old plant, the differences being due largely to the advance of the art since the time when the first power-house was equipped. The main points of difference are :—

(1) Closer generator regulation, the regulation on the new machines being 10 per cent., and on the old ones about 30 per cent.

(2) The entire plant will be operated from a single switchboard, instead of two.

(3) The feeders will be protected with automatic oil circuit-breakers.

* A paper read before the American Institute of Electrical Engineers by H. W. Buck.

Generators.

The first six generators to be installed will be similar in outline to those in the first plant, being of the external field type, with the nickel-steel revolving magnet ring. This machine is shown in assembly in Fig. 2. In appearance the most striking difference is in the omission of the iron bridges over the machines. This omission results from the collector rings being placed at the bottom of the dynamo shaft, instead of at the top.

As stated above, the principal difference in these new generators is in the matter of regulation, the regulation being nearly three times as close. This closer regulation was adopted in order to ensure constancy of voltage on the system with variations in load, and also to reduce to a minimum the unbalancing of the voltages on the different phases caused by difference in loads upon them. These points are of great importance on such a system as that of the Niagara Falls Power Company. Many electrical distribution systems are made up of a very large number of small consumers of power, and the actions of any one customer have little effect upon the voltage of the system; consequently, in such cases regulation is not of such vital importance. But the Niagara Falls system is made up of a comparatively small number of very large consumers of power, any one of whom may, by a change in his load, cause a serious disturbance on the circuits. Furthermore, it is unique in one of its

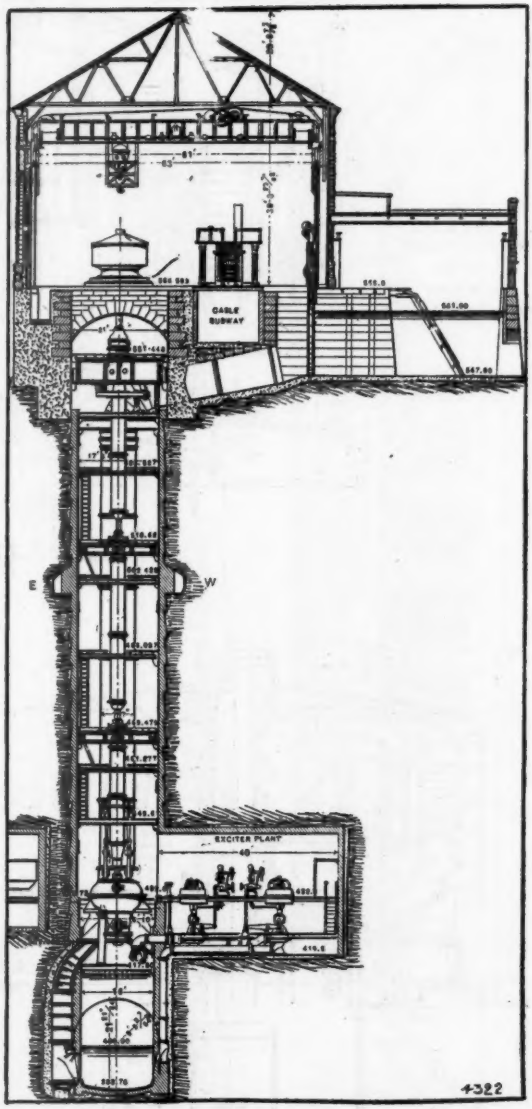


FIG. 1.—SECTION OF POWER-HOUSE NO. 2.

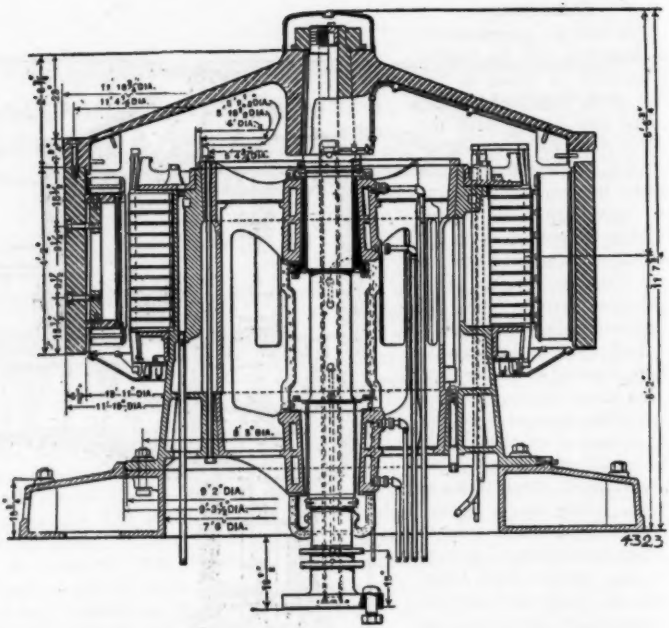


FIG. 2.
EXTERNAL FIELD
5,000-H.P.
GENERATOR,
POWER-HOUSE NO. 2.

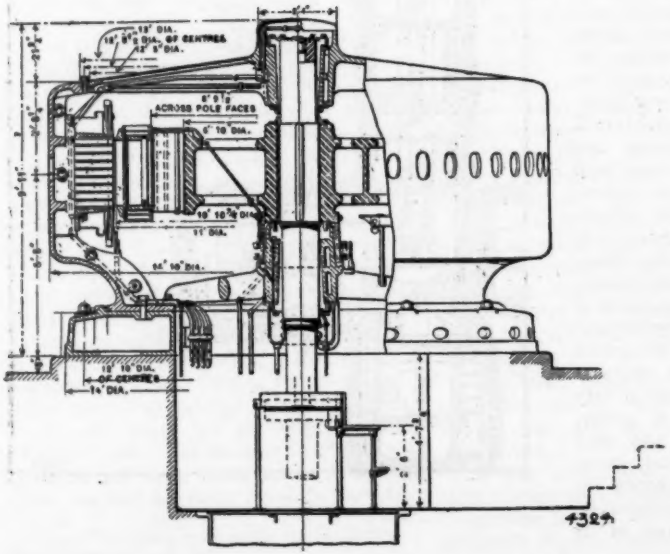


FIG. 3.
INTERNAL FIELD
5,000-H.P.
GENERATOR,
POWER-HOUSE NO. 2.

characteristics, in that much of the power is used on large single-phase electric furnaces, which take their power from one phase only. Since it is impossible to control these furnaces, so that at all times the same number shall be in operation from each of the two phases, inequality of load on the phases results and the voltages are unbalanced. This unbalancing is disastrous to polyphase, synchronous, and induction motors on the system; for the high-voltage phase tends to carry all the load, and the windings on this phase are overloaded. These results can be rendered inappreciable only by the use of generators of close regulation.

The armature winding is a two-circuit series closed winding, and consists of formed one-turn coils placed in open slots, with two coils to a slot. The conductor is made up of stranded cable pressed into rectangular shapes. This stranding of the conductor reduces eddy-current losses in the armature conductor itself, which exist in the case of a solid bar as used in the old machines. The open slot is also considered an advantage in a machine of such great length of armature core, for in the closed slot it is necessary to drive the armature bar with its insulation on throughout the length of the slot in order to put it in place. The system of interlacing the end windings used in the new machines gives strong construction to withstand the displacement strains caused by short circuits.

The system of ventilation is radically different in the

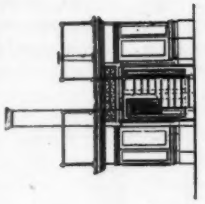


FIG. 5A.—END ELEVATION.

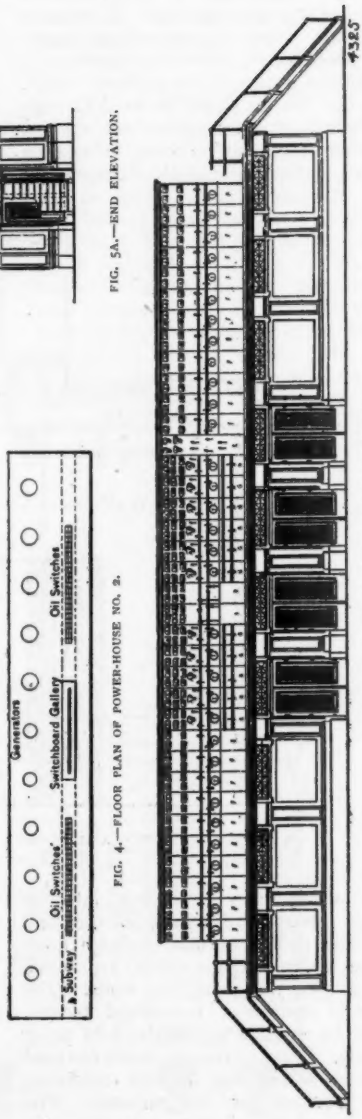


FIG. 5.—MAIN SWITCHBOARD: FRONT ELEVATION.

NOTES:—*G* Generator Panel, *F* Feeder Panel, *I* Interconnecting Panel, *E* Exciter Panel, *A* Ammeter, *V* Voltmeter, *W* Indicating Wattmeter, *T* Time Limit Relay, *FA* Field Ammeter.

FIG. 4.—FLOOR PLAN OF POWER-HOUSE NO. 2.

new machines. Referring to Fig. 2, a baffle-plate will be seen between the bottom of the armature winding and the bottom of the revolving field. This forces all the air, which is actuated by centrifugal pressure, to enter the machine at the bottom inside of the armature shell. From here the air passes outward through the air-ducts in the armature core, cooling the iron and the winding. It then continues outward radially between the tremendous. From tests which have thus far been made it is believed that these machines will run from 10 degs. to 15 degs. cooler than the old ones.

The generator equipment in this power-house is completed with five 5,000-h.p. machines of the internal revolving field type, shown in Fig. 3. It was decided that the last five machines of the installation should be of this type, on account of the much lower cost of building, simplicity

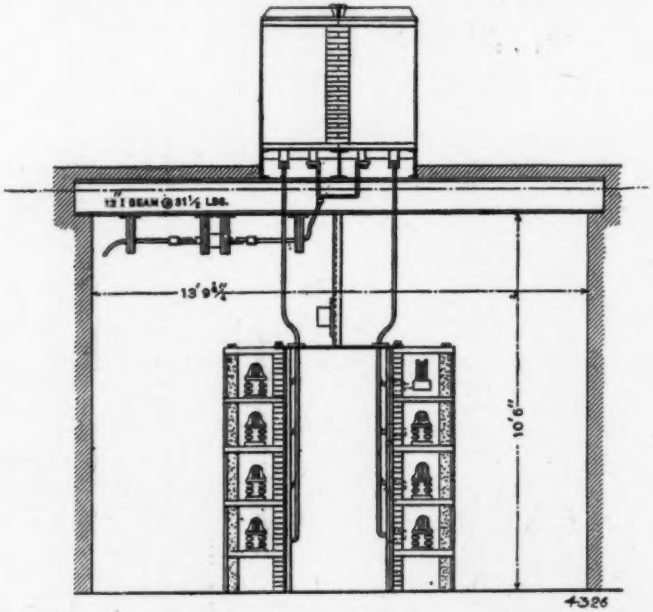


FIG. 6.—SECTION THROUGH CABLE SUBWAY UNDER OIL SWITCHES, SHOWING BUS-BARS,

layers of the field, winding into an annular space at the back of the field coils, and thence outward through holes in the magnet ring, which are bored in line with the pole-piece bolts. The action is that of a centrifugal blower, caused by the rotation of the field poles and ring. Some of the air passes outward at the top of the ring, through ventilating holes provided for the purpose. The operation of the air system is very satisfactory, and the blast of air secured is

of handling, and accessibility to the variou parts, as compared with the external field design. These machines are also wound for 2,300 volts, 25 cycles. two-phase, and operate at a speed of 250 revolutions per minute.

These machines will have the same regulation as the first six installed, and in other respects the electrical constants will be the same. From the drawing in Fig. 3 the construction may be clearly seen. It is similar to the standard horizontal shaft,

engine-driven alternators of well-known types, and its method of ventilation is the same. Recent improvements in the mechanical construction of generators have made this type possible at the rate of 250 revolutions per minute; and improvements in water-wheel governors have made permissible the lower fly-wheel effect incident to this design, and the consequent omission of the nickel steel ring of the first machines.

In the two power-houses, then, there will be three types of generator, but no trouble is expected in operating all the machines in parallel; the resultant regulation is the mean between the two. Idle current between the two types may be prevented by careful adjustment of the field current.

The guaranteed efficiency of the external field generators was:—Full load, 98 per cent.; three-quarter load, 97·3 per cent.; half load, 96 per cent. From actual test, the full-load efficiency has come out 98·15 per cent, which is probably the highest ever attained in an electrical generator.

Exciter Plant.

The exciter plant in the new power-house will be quite different in arrangement from the old one. The installation will be made complete with the exciter switchboard in a compartment recessed into the rock at the bottom of the main-wheel pit, as shown in Fig. 1. This position will eliminate the long shaft necessary with exciters placed on the main dynamo floor, and will simplify the operation of the plant. The equipment will consist of four 150-k.w. compound-wound vertical-shaft 220-volt exciters, each coupled to an independent turbine, placed directly

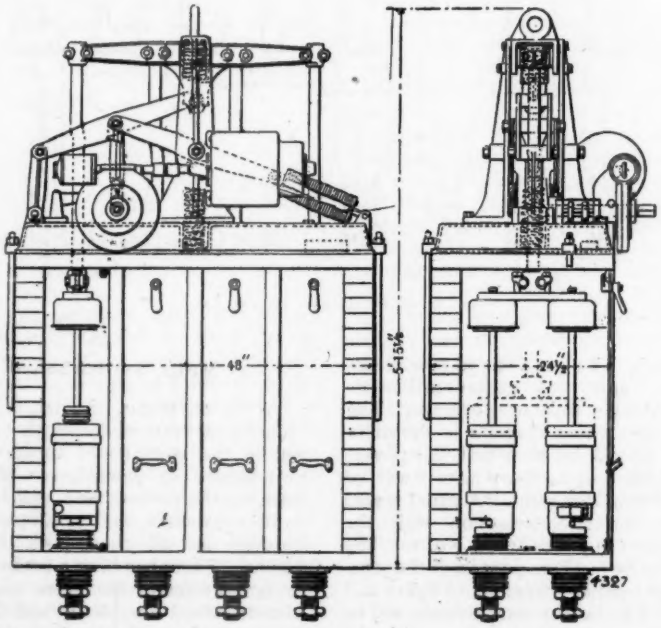


FIG. 7.—2,200-VOLT TWO-PHASE ELECTRICALLY OPERATED CIRCUIT-BREAKER.

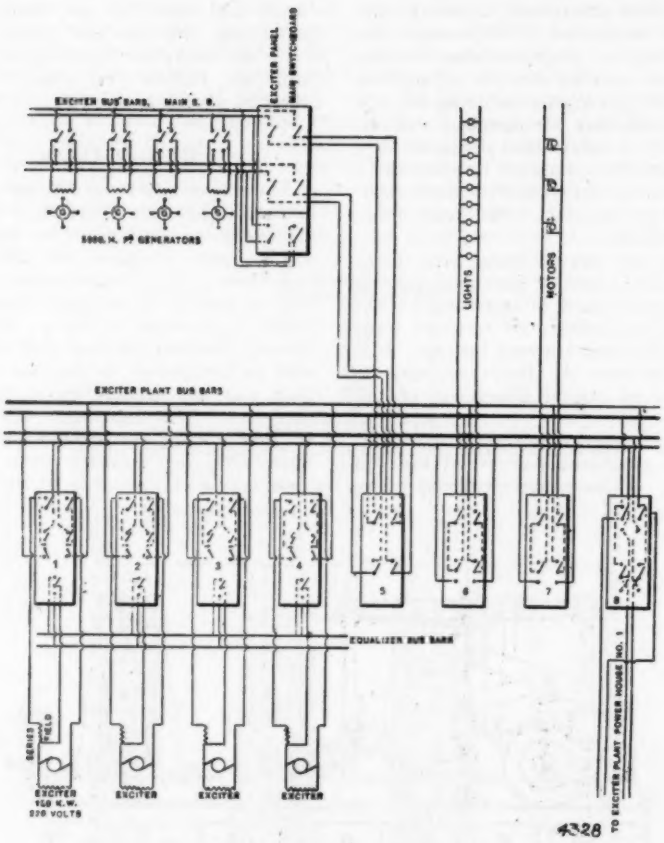


FIG. 8.—WIRING DIAGRAM, EXCITER PLANT.

underneath. The speed is 750 revolutions per min., and each exciter turbine is controlled by a separate governor. The exciter plant wiring diagram is shown in Fig. 8. It will be seen that the power-house lights and auxiliary motors will be operated from this plant. A panel is also provided for interconnection with the exciter plant in power-house No. 1. The double set of bus-bars permits of the separation of exciting circuits and lights and motors. The exciter compartment will be directly connected by telephone with the main-generator switchboard.

Main Switchboard.

As in all plants, the most important element for successful operation is the lay-out of the switchboard apparatus. The switchboard in power-house No. 2 has been carefully considered, and is believed to be convenient, and as simple as it can be made and still accomplish the desired results. There has been a tendency in the design of some of the recent large switch-boards toward complexity and the instal-lation of unessential appliances, which by their presence cause more trouble and

confusion *per se* than those which they are intended to prevent. This has been avoided as far as possible in the design of this board. Fig. 4 shows a plan of the power-house floor and the relative positions of generators, switchboard gallery, oil switches, and cable subway. Fig. 6 shows a section through the oil switches and cable subway, and indicates the location of the bus-bars placed in fireproof compartments. Fig. 5 shows a front elevation of the main switchboard gallery and controlling panels. In respect to switching, the power-house is divided into two parts, one of six generators and one of five. Each part has its own group of oil-switches and its double set of bus-bars. Fig. 10 will show the relations between the two groups, and also the interconnections with power-house No. 1. All the switches in the new power-house are the General Electric electrically operated oil-break type of the well-known design. This switch is shown in Fig. 7. All cables are led through the cable subway. They are heavily insulated with rubber, covered with a fireproof braid, and supported on brackets with porcelain clamp insulators.

(To be concluded.)

The Durban Floating Dock.

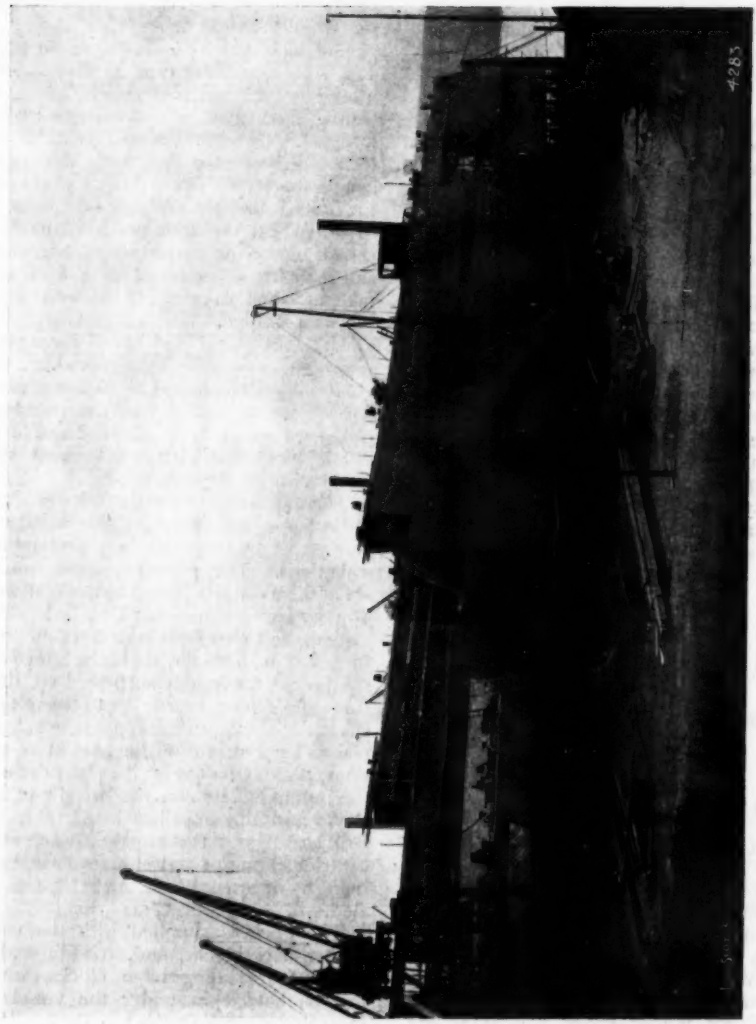
RECENT events in South Africa have brought Durban so much to the fore that the Harbour Board finds that the shipping could no longer await the tedious construction of a masonry dock. The construction of a floating dock was therefore decided upon, and Messrs. Clark & Standfield, of 11, Victoria Street, Westminster, were commissioned by the Agent-General for Natal, Sir Walter Peace, K.C.M.G., late last autumn to prepare plans and obtain tenders for the construction and delivery in complete working order at Durban of a floating dock capable of lifting vessels up to 4,500 tons dead weight. At the beginning of the present year the contract was placed with C. S. Swan & Hunter, Ltd., and within seven months the dock, practically complete in all respects, was successfully launched.

The dock, which is illustrated on page 340, is of the same type as that at His Majesty's dockyard at Bermuda, but is, of course, much smaller. Its extreme length is 375 ft. over platforms, and its width 87 ft., and it is divided into forty water-tight compartments. The distance between the guard timbers on the side walls is 61 ft., so that the dock can accommodate vessels up to 60 ft. beam, whilst, when still retaining a free-board of 4 ft., it can take a vessel drawing 18 ft. over keel-blocks 4 ft. high.

The dock proper consists of three pontoons and two side walls, to which the pontoons are connected by means of movable joints, so that any of the pontoons can, when required, be removed and lifted by the dock itself, thus making it self-docking in all its parts.

The machinery of the dock is contained in the upper portion of the side walls, and consists of two separate but identical installations. The pumping arrangements are of the usual type, fitted by the Wallsend Slipway and Engineering Co., Ltd. The engines, supplied from boilers 10 ft. long by 9 ft. 6 in. diameter, are of the horizontal compound tandem type, placed on their sides and driven directly on to the vertical spindle of the centrifugal pumps, which are placed right down at the bottom of the dock, directly on top of the main drain of the pumping system, the weight of the shafts and the impellers being taken on ball bearings at the engine deck. The centrifugal pumps and engines have been built by Messrs. W. H. Allen & Co., of Bedford.

The dock is supplied with the usual timber keel blocks, and, in addition, has twenty-four sliding bilge blocks, which can be hauled in under the vessel by means of ropes from the top deck. It is further provided with four mechanical side shores, also worked by hand wheels from the top deck, by means of which a vessel can be centred on the dock. Four steam capstans—two on each wall—



THE DURBAN FLOATING DOCK

are provided for hauling the vessel into the dock, and the numerous bollards and timber heads are provided on the face of the walls for making her fast to.

The dock is provided with a small but complete electric light installation, which will enable work to be carried out on ships through all the hours of both night and day. The electrical installation has been provided by Messrs. W. H. Allen, Sons & Co., Ltd., of Bedford. The system used is the direct current, at a tension of 110 volts, the electric cables being all contained in steel tubes to prevent injury, with the exception of the cable which crosses the deck, which is drawn into lead and suitably armoured.

New Steam Motor Vehicles.

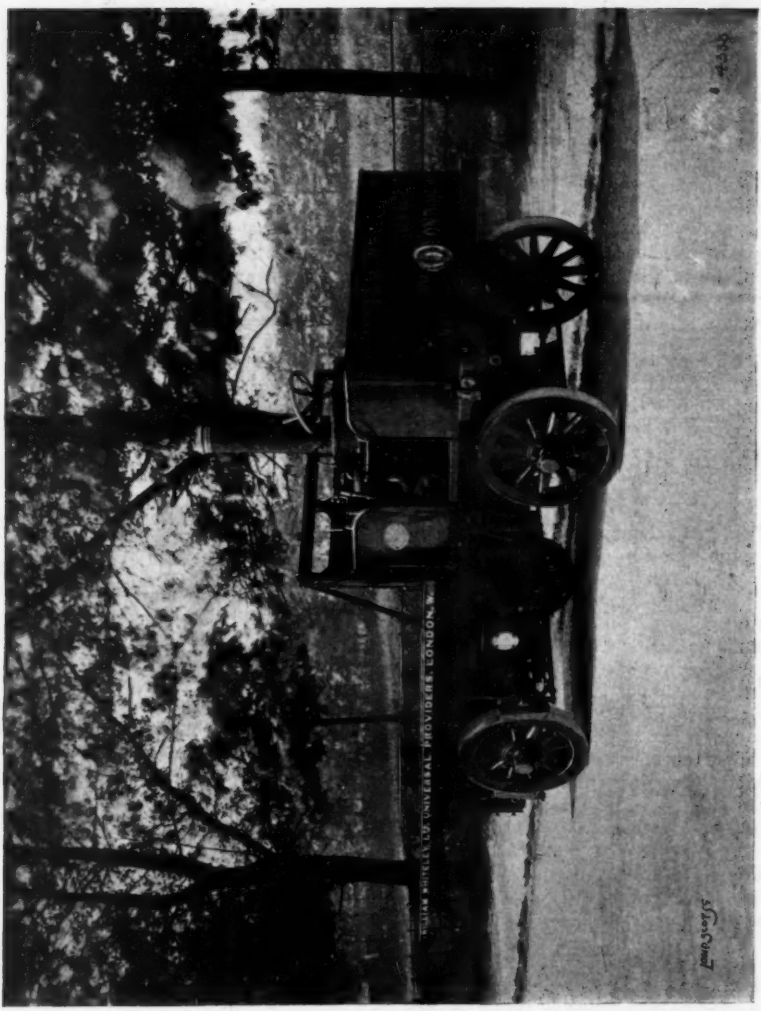
THE general similarity which pervades the motor vehicles successfully negotiating the heavy-traction problem, throws into greater prominence any definite departure from the fundamental principles so far followed.

It is characteristic of all the present cars that they have driving and steering wheels independent of one another; moreover, they are so designed that the addition of the loads, practically speaking, adds no further weight to the steering-wheels. The reason for this is, obviously, so as not to exceed a certain load on the steerers, as, beyond some definite weight—fixed by the resistance of the road wheels to be moved—it is impossible to arrange the Ackermann steering gear so that these wheels can have their direction of running altered by the driver quickly enough to allow the car to be manœuvred through traffic at the speeds permissible for these cars. Since the lorry designed by A. W. Brightmore, D.Sc.,* with the help of Mr. R. W. H. Bailey, and constructed by Messrs. T. Coulthard & Co., Preston, combines the driving and steering functions in the same pair of wheels, and makes the steering altogether independent of the load on the steering wheels, it presents an essential departure from the ordinary type, not only in combining the driving and steering in the same wheels, but also in capacity for load carrying. The latter feature obtains in this car by virtue of its design allowing the load to be equally distributed on all four wheels, so reducing the wear and tear on the road, and enabling the two axles to make any angle with each other in vertical planes necessary to accommodate unevenness in the surface of the ground. The difficulty which has hitherto prevented this combination of driving and steering was, that if sufficient load was arranged over the wheels to get the necessary tractive effort, it became impossible to provide a sufficiently quick hand-steering gear; and, of course, without sufficient load on the drivers, they would merely revolve on the road without propelling the vehicle. This difficulty is met in the Brightmore lorry by a distinct departure from previous practice; for, instead of having a direct mechanical arrangement for steering by actually pulling the fore-carriage round to its required altered direction, the steering is effected by means of brakes (which can be applied to either side at will) between the compensating gear and road wheels. It then becomes a problem in dynamics—a varying force exerted for a given time on one or other brake, causes a deflection of the forecarriage towards that direction.

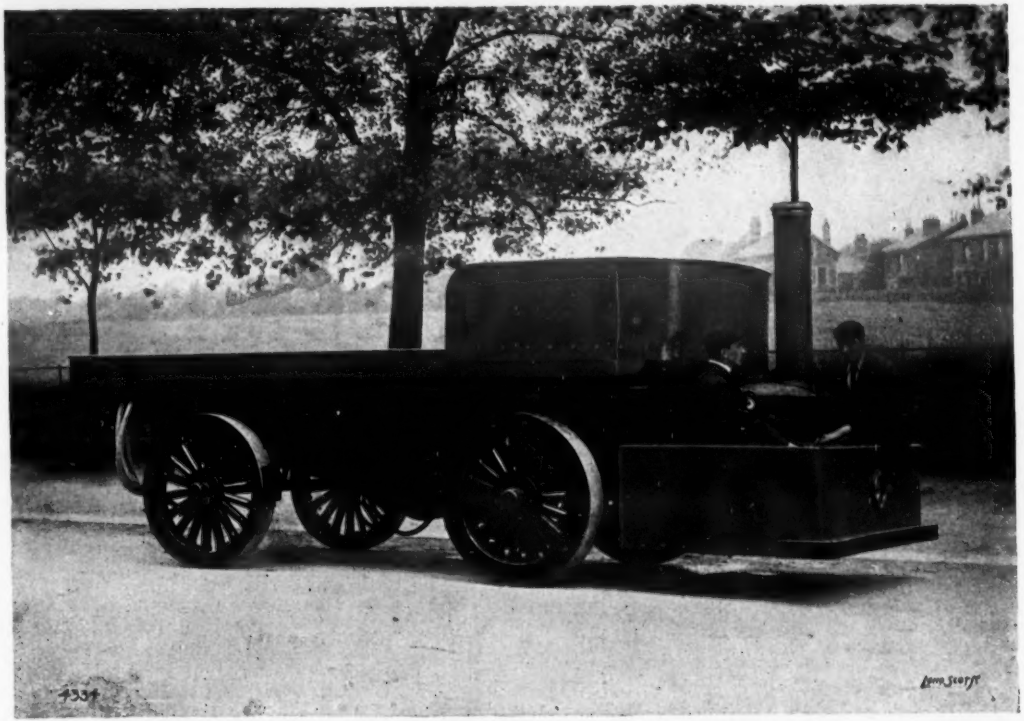
In order that the principle can be fully grasped, it would be well to describe the working of the car in more detail.

The engine, transmission gear, boiler, and operator are all carried on the turning fore-carriage. This is quite independent of the load-carrying platform, except for a large ball-head which allows the fore-carriage to swivel relatively to the platform, and a pin joint in the same horizontal line which carries a slide that moves round a horizontal circular arc to prevent the fore-carriage rocking either backward or forward in the line of its motion. The pin joint is in the fore-

* *Vide* the Supplement Plate.



STEAM MOTOR LORRY, CONSTRUCTED BY MESSRS. T. COULTHARD AND CO., LTD., PRESTON, FOR MESSRS. WM. WHITELEY AND CO., LTD.



DR. BRIGHTMORE'S STEAM LORRY, CONSTRUCTED BY MESSRS. T. COULTHARD & CO., Ltd.

carriage, and the arc is carried on the main or load-carrying frame. The fore-carriage frame is of a built-up trussed form, the engine and gear being all in a self-contained oil-tight casing, suspended at three points therefrom. The boiler is of the vertical fire-tube type, but differs radically in its proportions from the same kind of boilers used on other steam lorries. Its depth is small, since it has to come under the load-carrying platform, and the uptake is carried forward horizontally to clear this top frame and then upwards.

The steam exhausts into a feed-water heating arrangement, which acts as a muffler, and thence to the vertical uptake, where it mingles with the hot gases from the fire, and passes off in a superheated and quite invisible state. The horizontal part of the flue has a very good equalising effect on the draught induced by the exhaust steam, and also effectually arrests all sparks. There are two pumps, one driven off the engine, and the other, a direct-acting steam pump, is fitted as a reserve in case of accident to the former, and is, moreover, convenient for use when the engine is not working. The check valves are combined with plug valves, so that the check itself can be cut off from the boiler and taken out and examined whilst the boiler is under steam. The safety valve is arranged to blow off into the water tank to avoid noise. A special wash-out aperture is provided on the top tube plate of the boiler, and there are three wash-out plugs and a blow-off cock on the bottom shell-plate.

Coke or coal is used for firing, and is carried on the fore-carriage on the opposite side to the driver. The only part necessary for the running of the vehicle not on the fore-carriage is the water-tank, and this is carried over the back wheels and coupled to the pumps by flexible rubber pipes.

The steering is effected by a hand-wheel operating through a worm, worm-wheel and levers, a horizontal transverse shaft carrying two bell-crank levers set opposite ways, which apply the brakes to the live drums bolted to the chain pinions on either side of the compensating gear. According to the power exerted, the speed of turning can be rendered fast or slow as required. In order to prevent the vehicle turning when one wheel is in a soft place and the other wheel is on a hard surface, a resistance is introduced between the two driving wheels or between the horizontal arc and slide before mentioned. The car answers so readily to its steering that very sharp corners, even when they occur alternately on opposite sides can be safely negotiated at a speed impossible with other methods of steering. All the levers and gear necessary for handling the car are placed so that the driver need not leave his seat or turn round to use them.

Two brakes for stopping the car are provided—one on the front wheels, a special compensating brake, and a plain block brake acting on the tyres of the back wheels. The engine is one of the standard compounds of Messrs. T. Coulthard & Co., Ltd., Preston, having ordinary reversing gear. A pinion on the crank-shaft drives through a spur wheel the second motion shaft, which again, through one of two pinions sliding on a square, drives through the usual compensating gear the chain pinions (fast or slow, according to which is in need); and these in turn drive the road wheels, by means of Renold's silent chains. All the gearing is machine-cut, and as it runs in an oil bath it forms a very efficient power transmission. The bearings are made specially large, to ensure long life to the car and to keep the pitch lines of the gear correct. The two resulting speeds are three and six miles an hour respectively, the change from the one to the other being effected from the driver's seat—the operation in practice being very easily performed.

The advantages of the car lie in its short wheel base, large angle of lock for steering, and long length of platform. In the car illustrated the wheel base is only 8 ft., whilst the platform is 16 ft. long. The result is that the car can be completely turned in a circle of 27 ft. diameter. It is not, however, in light work that this system shows to the best advantage, but in the handling of heavy loads, because each of the four wheels always carries its fair share of the load, and the effort of steering is a negligible factor.

At the point where the back-driving car begins to fail owing to its short platform, long wheel base with all the load on two wheels, and the big effort required in steering, the peculiar advantages of this front-driving, momentum-steering design become most apparent. In the Brightmore system, with a 10-ft. 6-in. wheel base, it is possible to get a 21-ft. platform, and each wheel takes its proper proportion of the load, so that excessive pressures on the loads are avoided, whereas, allowing the same total length of a car for a back-driven front-steering type, the largest cars only give about 15 ft. platform length, the wheel base being about 12 ft., and most of the load on the rear wheels. Another strong feature in the design is that the engine and gear being altogether independent of the load and totally free from all twisting movements, the car should have an increased life; also, when there is no load up, since four-fifths of the weight is on the driving wheels, there is no tendency to skid owing to lack of adhesion uphill. After very extensive running, under all conditions of weather and road surfaces, the car has given entire satisfaction.

The subject of the illustration on page 342 is a steam vehicle, also constructed by Messrs. T. Coulthard & Co., Ltd., Preston, for Messrs. Wm. Whiteley, Ltd., of Westbourne Grove. This vehicle, which is capable of carrying up to 4 tons, has been designed to come within the tare weight limit imposed by the Locomotives on Highways Act, and is of a type which should prove very useful to a large number of firms in the London district.

The leading dimensions are—

Length over all	17 ft. 6 ins.
Width over all	6 ft. 6 ins.
Height over chimney	8 ft. 6 ins.
Platform	11 ft. by 6 ft.
Fuel-bunker capacity	4 cwts., 35 mls.
Water-tank capacity	14 to 15 mls. according to the nature of the roads and grades.
Speeds, fast and slow	7 and 3 mls.

The carrying capacity of the vehicle on fair macadam or paved roads, and on grades not exceeding 10 per cent., is 3 to 4 tons; but on bad roads, or grades of more than 10 per cent., the load must be reduced to suit the roads.

The limit of grade which the makers guarantee the vehicle to safely ascend is 10 per cent., with a 3- to 4-ton load.

The various handles for steering, reversing, starting, also the main steam-valve and boiler-feed handles, are all in direct range of the driver.

The main frame of the vehicle is of channel steel, braced and constructed so as to carry the whole of the machinery, boiler and tanks, the frame itself being supported on the axles by long laminated springs.

The boiler is of an improved vertical fire-tube type, and mounted with the most approved fittings. It is constructed for a working pressure of 200 lbs. per square inch, and hydraulically tested to 400 lbs. per sq. in. With this boiler, which is under the inspection of the National Boiler and General Insurance Company, is included an insurance policy for £1,000 for twelve months.

The boiler-feed pump is directly connected to the compensating gear shaft, and an independent steam pump is fitted as an emergency feed.

The engine is compound fitted, with link reversing gear, and capable of developing 20 h.-p. with ease. The casing, which is oil-tight, is extended so as to carry enclosed all the various reduction and compensating gears and shafts. This ensures perfect lubrication to all the working parts.

The transmission of the drive to the road wheels is by means of Hans Renold's roller chain.

The wheels are of the gun-carriage pattern, and fitted with steel hubs, oak spokes, and ash felloes, the width of tyres being 6 ins. and 4 ins.

They are fitted with a triangular attachment, whereby the drive is taken direct to the wheel felloes.

A double-acting brake is fitted to the road driving wheels, and is capable of holding the vehicle on any grade.

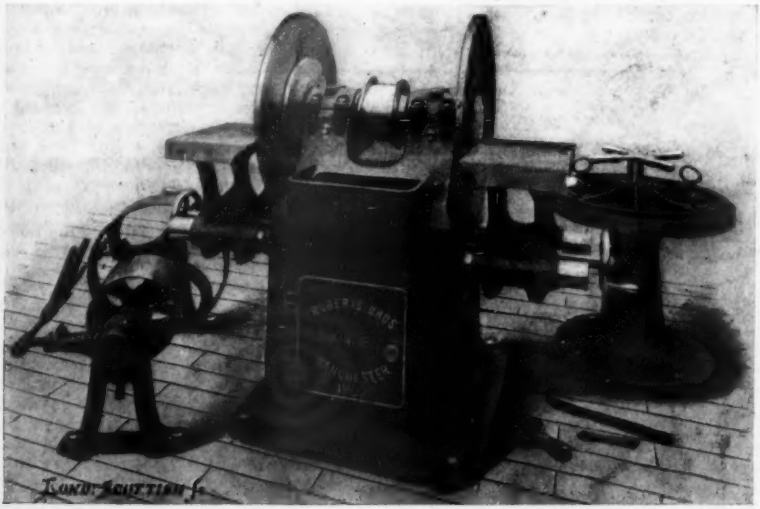
The fuel used may be either coal or coke.

Large Disc Surface Grinder.

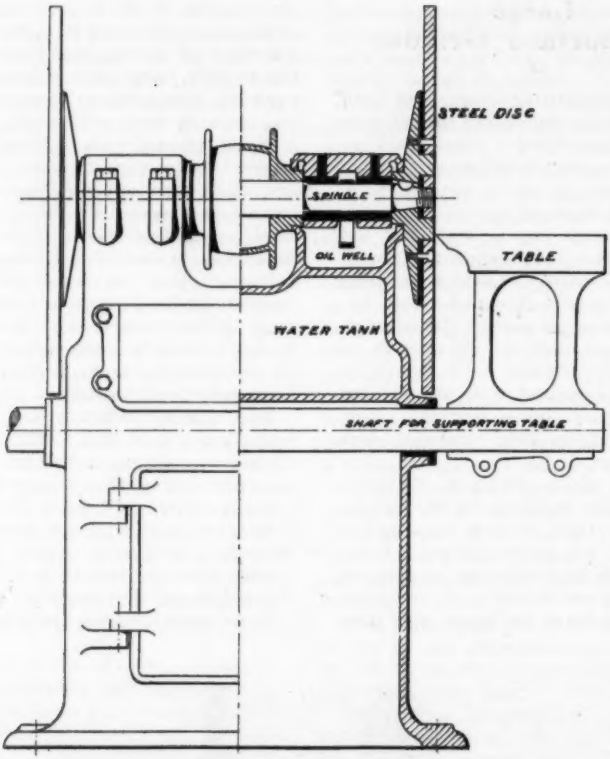
THE accompanying illustrations show one of the largest disc grinders ever yet constructed. This machine, which is capable of taking an emery paper disc up to 28 in. across, is, in common with the 24-in. machine, specially adapted for large engine work and the heavier classes of engineering work generally. Owing to its size and the speed for which it has been designed to run, viz., 1,000 revolutions per minute, special attention has been paid to the details in design and construction. The spindle is hardened and ground true, and runs in renewable cast iron bearings, 2-in. diameter by 6½-in. long, provided with ring lubricators.

The back plates are 15-in. diameter, fitted on conical bearings on the spindle, and held up tight by sunk nuts, and in addition they are securely keyed, so that it is absolutely impossible for them to run loose. They are turned up on their own spindle. To them the 28-in. steel discs are secured by three steel driving pins and three counter-sunk head screws. The efficiency of the machine depends upon these discs, and the greatest care is exercised to make them perfect in balance and true in face. They are made of specially tempered steel, rough turned several times to abolish all risk of buckling and distortion, and they are ultimately accurately finished off, being practically revolving surface plates. In order to reduce the noise made by the machine, vulcanite fibre washers are clamped between the back plates and discs, which break up the sound waves and render the machine perfectly noiseless, that humming so objectionable in high-speed machines being entirely eliminated.

The spindle pulley is 8-in. diameter, and takes a 4-in. belt. The tables are 16 ins. by 12 ins., carried on two 3-in. diameter steel spindles, along which they may be moved by a screw and hand-wheel, to which a micrometer for adjustment may be applied, if desired. The height of the spindle from the floor is 3 ft. 3 ins., and the weight of the machine is 28 cwt. This machine has been specially designed



LARGE DISC SURFACE GRINDER.



DETAILS OF DISC SURFACE GRINDER.

and constructed by Messrs. Roberts Bros., of Dukinfield, Manchester, for one of our largest railway companies, and is to be used for grinding up locomotive axle boxes. Smaller sizes of this machine are suitable not only for operating on a large and varied amount of work, hitherto carried out on shaping and milling machines, but for rendering considerable assistance in the fitting and erecting shop.

Engineering Notes From all Sources

Electricity Direct from Coal.

THE *Journal of the Franklin Institute* gives an account of the latest attempt to produce energy directly from coal. In this process, which is the subject of a patent by Mr. Hugo Johe, of Chicago, a retort is employed, which is surrounded by a cylindrical case containing a battery of four cells, each subdivided into three sections by partitions of porous coal, and containing respectively nitric acid, sulphuric acid, and ferrous chloride solution. An electrode is immersed in the nitric acid, and a lead electrode in the chloride solution. The operations followed may be thus briefly described:—A suitable quantity of sulphate of lead is placed in the retort with a quantity of coal nearly sufficient to reduce the sulphate to sulphide, and the mixture is then heated until all the coal is oxidised. The sulphide is freed from impurities which may have been brought into it by the coal, and is then mixed with sulphate of lead in sufficient quantity to yield metallic lead and sulphur dioxide, which reduction is effected by again applying fuel heat to the retort. The sulphur dioxide passes through a pipe into the larger section of the several cells, reducing the ferric chloride therein to ferrous chloride. Previous to this the generation of the electric current is started by putting the lead electrodes into the larger section, and suitably connecting them with the carbon electrodes. The current may be considered as consisting of two currents, one generated by the action of the ferric chloride of the lead electrode, and the other by the action of the nitric acid through the interposed porous walls, and sulphuric acid by means of molecular exchange of ferrous oxide. The flow of sulphur dioxide is so regulated that the sulphuric acid formed is not more than sufficient to decompose the chloride of lead formed in the battery reaction. The lead in the retort is allowed to flow into a pan, where it is suitably shaped or solidified for an electrode. The sulphate of lead deposited by the battery is allowed to accumulate, and at intervals is drawn off by means of syphons, and the deposit of sulphate of lead electrode removed. The temperature of the battery is regulated so that the nitric acid which enters into the sulphuric section is evaporated, the vapours being passed through a condenser, and there condensed again to nitric acid, flowing back into the nitric acid sections through a pipe. This process of distillation, oxidation, and condensation is kept up by regulating the temperature of the battery and supplying sufficient cooling water to the condenser. Thus oxygen is supplied to the nitric acid, while the generation of electric energy with consumption of oxygen goes on. The e.m.f. of the cell at 100 degs. Cent. is said to be about 1·75 volts.—*Journal of the Franklin Institute*, May, 1902.

Ball-bearing Ordnance.

A BRIEF account of a gun that promises to revolutionise the manufacture of army ordnance is given by *Popular Mechanics*, Chicago. The new gun is the invention of Captain Orlan Clyde Cullen, 700 7th street, N. W., Washington, D. C., and is known as the "Cullen Ball-Bearing Rifle Gun." During the Cuban War the captain had witnessed the jamming of two Hotchkiss guns from overheating in action. How to build a gun that would not kick or heat up was a question that he tried to answer, and the solution finally came to him in the idea of the ball-bearing rifle. On his return to the United States a company was formed, and the manufacture of the new weapon was commenced. From the report of a recent competitive trial of a two-pounder Cullen gun with Maxim, Hotchkiss, and Driggs guns of similar calibre, it may be gathered that the invention is worth investigation. The report

states :—"All four guns were fired at a plate of nickel steel 20 ft. square and 1⅞ in. thick. The plate was 3,000 yds. from guns. The ball-bearing gun was fired, and the projectile struck and penetrated plate (3 ft. from centre of target), ricochetted, and was picked up 1,620 yds. beyond, embedded in the dirt 17 ins., making a total range of 4,626 yds., after getting through 1⅞ in. of best armour plate. The three other guns before mentioned, when fired, hit the plate in two instances (the Driggs and Hotchkiss, with their projectiles, failed to penetrate the plate, and glanced into the earth in front of it). The Maxim projectile hit the plate and stuck in it with the nose of the projectile extending ⅛ of an inch through it."—*Popular Mechanics*, Chicago, June 14, 1902.

The Solidification of Filings and Turnings.

ENGINEERS are familiar with, and have taken advantage of, the "flow of metals" in such industries as the manufacture of lead pipes, hot and cold punched nuts, but it is not generally known that metallic powders, filings, and turnings can be compacted into solid masses by heavy pressure. Some interesting experiments of this kind are mentioned in the *Journal of the Franklin Institute*, as having recently been conducted at McGill University, Montreal, by Professors Anderson and Nicholson. They consist of taking filings or turnings of brass, iron, copper, tin and other metals, and, by means of pressure, securing therefrom solid bars of metal, differing very little in appearance and strength from those to be seen, as a rule, in hardware stores and machine shops. The pressure brought to bear upon the filings or shavings is about 78,300 pounds to the square inch, and this has the effect of welding them into a solid whole, or bar of metal. The filings are first encased in a jacket made of steel, which is conical in shape. Pressure is continued for about ten minutes, at the end of which time the tube is removed from the cylinder and opened, when a solid cylindrical bar of brass, lead, tin, iron, or copper, as the case may be, is found. These bars differ very little in appearance from those which have been made either by welding or casting, and appear to be equally strong as the latter. Some idea of the success of the experiment may be gathered from the fact that it has been found quite easy to solidify the filings of Pittsburgh brass, probably the hardest brass manufactured at the present day. This metal is found to yield quite quite readily to pressure.—*Journal of the Franklin Institute*, April, 1902.

War Office Motor-Lorry Trials.

THE Committee appointed by the War Office authorities to test the capabilities of sundry self-propelling lorries for military use, has recently been issued. As a result of their investigations, the Committee awarded the prizes as follows :—First, £500, to The Thorneycroft Steam Wagon Co., Chiswick ; Second, £250, to Messrs. Edwin Foden & Co., Ltd., Sandbach ; Third, £100, to The Straker Steam Vehicle Co., London and Bristol. They further recommended that the lorries made by the first and second mentioned firms should be purchased for army use. Comparing the results obtained, the Committee state that the 5-ton load, if carried in wagons of service pattern, would overload three GS wagons requiring 12 draught horses, besides riding horses whose pace would not ordinarily exceed three miles an hour. The motor-lorries each took this load at six miles an hour. Moreover, the marching of 197 miles in six consecutive days—as carried out by the lorries—would not have been accomplished by horses, even at the speed stated, without the assistance of spare horses. The Committee are satisfied that mechanical transport is well worth a more extended trial. The trials caused a slight alteration to previously existing views. It is now considered that for rapid distribution among troops, and near the front of an army, a lorry without trailer is preferable ; whereas they are of opinion that for the heavier work of moving stores in large quantities to the depôts a powerful tractor, drawing a train of wagons, will be found most suitable. Finally, the Committee recommend that they be empowered to take steps to obtain for trial a lorry or lorries on the following lines :—"To carry three tons, driven by an internal combustion engine burning heavy oil only ; weight as light as consistent with due adhesion ; wheels large and broad, and fitted with a means for rapidly applying numerous "spuds" for use on boggy ground. Speed up to eight miles an hour ; large platform area." Finally, the Committee beg to call special attention to the demonstration afforded by these trials, of the entire harmlessness to roads of vehicles considerably exceeding in weight and road-speed the limits allowed by the present regulations on the subject, and also fitted with wheels to which road strips have been fixed, so long as these wheels are of large diameter and have tyres of considerable width. It has now been proved that the existing regulations are unnecessarily restrictive, whilst they stand in the way of the development of a most important method of

transport and branch of industry. The Committee strongly recommend that this matter be brought to the notice of the proper authorities, feeling confident that the removal of these restrictions will tend to assimilate the commercial and military types of vehicles, and is not only important therefore from a service point of view, but also will have a most beneficial effect on the manufacturing industries of the country and its commercial development generally. The appendices to the Report contain much useful and interesting information on various details connected with the trials.—*The Engineer*, Sept. 5th, 1902.

The Real Nature of Electricity.

A NEW theory intended to account for the phenomena of electricity and magnetism, is put forward by Mr. Arthur A. Skeels, in a contribution to the Civil Engineers' Club of Cleveland, U.S.A., in May last, reprinted in the *Journal of the Association of Engineering Societies*. The basis of the theory is the assumption that atoms are groups of smaller parts, which may be termed "sub-atoms," and that as there are gases made up of atoms, so there are "sub-gases" made up of sub-atoms. It is further assumed that as there is only one general atmosphere, so there is one general sub-gas and one general ether, all of nearly constant composition. Then it is argued that as there are disturbances in the air, so there are similar disturbances and motions in the sub-gas and ether, known to us as light, heat, electricity, and magnetism. A study of the phenomena of electricity and magnetism led the author to believe that these could not be motions in the same medium, and that the former is a motion in the sub-gas, while the latter is a motion in the ether. The functions of the sub-gas and ether are thus explained :—When an electric current is passing along a copper wire, the condensed sub-gas, permeating its substance and sheathing its surface, acts like a shaft and conveys power as an ordinary steel shaft does in a machine shop. The friction of the sub-gas, in flowing through and around the material of the wire, develops heat in proportion to the current. There is also friction between the sub-gas and the ether about the wire, so that rotation of the sub-gas causes rotation of the ether, the angular velocity of which bears a direct relation to the distance from the actuating force. While the current is practically confined to the wire, its influence in the ether extends indefinitely on all sides, and so the establishment of an induced current is explained. The general theory accounts for the piercing of insulators by suddenly induced currents of high electromotive force by the supposition that, owing to inertia, it is more difficult to suddenly set the long "sub-gas shaft" of the conductor in rotation than to pierce the insulator ; and it also explains the fact that equally good insulators do not form equally good dielectrics, on the ground that one property refers to the resistance to ether whirls, while the other refers to the resistance of sub-gas whirls. Other illustrations in the paper relate to applications of the theory to alternating currents, electrolysis, magnetic waves, and X-rays. This subject is too extensive for complete treatment in a single paper, but the examples and conclusions of the author are worthy of consideration.—*Journal of the Association of Engineering Societies*, May, 1902.

Electric Equipment in Modern Machine Shops.

IN a paper read before the Engineers' Society of Western Pennsylvania, Mr. F. E. Duncan discusses the important part played by electrical machinery in the equipment of the modern machine shop, a subject clearly demanding the closest attention of all manufacturing firms. The author admits that the one great difficulty from the electrical side of this question is that of obtaining necessary speed variation. This is a serious obstacle owing to the great variations required. On the other hand he points out that such appliances as tapping machines, bolt-cutters, pipe-cutters, pipe-screwing machines, power shears, emery wheels, grindstones, buffing apparatus, foundry blowers, etc., do not require more variation in speed than can be obtained by shunt field regulation. Amongst incidental, but in no way fundamental, mechanical difficulties tending to discourage the introduction of electric driving, the following are mentioned by the author :—(1) The present design of machines for belt operation necessitates new patterns for many parts ; (2) the greater first cost of motor-driven tools ; (3) the strength of many tools as now constructed is not sufficient to stand positive motor operation. One of the most important advances made in the electric driving of machine tools is the entire elimination of belts and pulleys in planing machines, by the use of direct connected motors and magnetic clutches. In the writer's opinion, the crying need of the day is for an electro-mechanical tool-making firm that will be prepared to devote its entire energies to the manufacture of electrically driven apparatus on a comprehensive scale, so that progressive manufacturers may be able to procure and

install complete motor-driven equipments, a course which at the present time is practically impossible.—*Modern Machinery*, July, 1902.

Concrete Steel.

NUMEROUS tests have shown the high resistance of concrete when reinforced by steel, but knowledge of the laws determining the relations of stresses to deformations is not yet sufficient for the formulation of an approved theory applicable to concrete steel structures. Some useful information on the subject is contained in a paper by Prof. Brik, of which a condensed report is given by *The Engineering Record*. It is argued by the author that the great resistance by the combination is due to the characteristic behaviour of the two unlike constituents, the steel and the concrete adhering so strongly to each other that the composite structure acts as a homogeneous material. This adhesion offers to the concrete resistance against sliding along the steel, and thereby transfers the inner forces from one material to the other, and so uniform behaviour is the result. An established value of the modulus of elasticity of concrete-steel is a desideratum, for the factor in question is one of much importance in all static computations. The modulus is necessarily dependent on the quality of the ingredients, the proportions of the mixture, and the age of the test specimens, and it is not constant in the presence of varying stresses. According to tests cited in the paper, it seems that, everything else being equal, steel embedded in concrete has little or no effect on the co-efficient of elasticity, and that the co-efficient of deformation, instead of that of elasticity, should be used in computations of concrete steel structures. In addition to his theoretical discussion of the subject, Prof. Brik includes some extracts from the building codes of German cities, which will be found useful for the computation of concrete-steel floors and columns.—*The Engineering Record*, August 23, 1902.

Electric Power in Iron and Steel Industries.

ONE of the most valuable papers brought before the recent meeting of the Iron and Steel Institute is by Mr. D. Selby-Bigge, who deals with actual facts and figures, collected from a great number of different sources, relating to the application of electric power in industrial establishments. As examples of the valuable practical data presented by the author, the following extracts will be interesting. In 1901, the working cost of Brown's steam cranes on the Hamburg quayside was 11*s.* 4*d.* per ten-hour run, whereas that of electric cranes was only 7*s.*; in 1898, the cost per ton lifted was 2¾*d.* by steam and barely 1*d.* by electric power. At the works of the Westinghouse Air Brake Co., U.S.A., the replacement of steam engines by an alternating-current system resulted in 40 per cent. saving in steam consumption. Before a meeting of the Franklin Institute, it was stated that if electric driving were abandoned at the Baldwin works, the manufactured product would cost from 20 to 25 per cent. more, and the floor space would have to be increased 40 per cent. to maintain the present output. The economy resulting from the substitution of electric power for steam is further shown by the fact that at Messrs. Vickers, Sons & Maxim's works at Barrow, the coal consumption was reduced by one half, notwithstanding the fact that many new machines had been added and the amount of lighting had been more than doubled. Therefore, the true saving was nearer 60 per cent. than 50 per cent. Some economies effected at collieries by the adoption of electric power are remarkable. Thus, one in South Durham saved £1,500 per annum; another in Northumberland saved £1,500 to £1,800 in the same period; and another in Scotland effected an annual saving of over £3,000, so that the total cost of the plant was covered in two years. The author shows that while the greatest savings are evidenced in cases where the units of power are the most subdivided, there are, nevertheless, enormous advantages to be derived in the case of intermittently working machinery with variable loads. In a later part of his paper the author dwells upon the importance of utilising the waste gases from blast furnaces. Gas engines have been driven in this way, and these should be made to actuate blowing engines or dynamos from which current could be distributed throughout the works. At Seraing, a Cockerill gas engine of large size used about 100 cub. ft. of average blast furnace gas per effective horse-power per hour. This was less than one-fourth of the gas that would have been burnt in the boilers of good modern condensing steam engines. In Great Britain really large sources of water-power are practically unknown, and the sources from which electricity can be produced most economically will be undoubtedly due to the development of large power gas engines making use of the surplus gases from the blast furnaces, which would otherwise be wasted. Gas engines have been made, and are at work, of 1,200 horse-power, and an engine of this type is now building for no less than 2,500 horse-power. In the concluding part of his paper, the author

deals with the development of electric power companies, and the prospects of electric enterprise in this country. In a district of a fairly concentrated character, or in which a large number of small works and factories exists, it might be profitable for the works to take 100 to 200 horse-power at 1*d.* per unit. In districts where all the works are of an extensive character and absorb 500 to 5,000 horse-power, it would be more profitable for works owners to produce their own power. With the best modern plant, and generating stations of 400 horse-power and upwards, the cost of production should not exceed ½*d.* per Board of Trade unit, inclusive of depreciation and interest on the capital outlay. With blast-furnace waste gases the figure would be less. In concluding, the author referred to the slowness with which Great Britain had made use of the advantages which electricity supplied, and the obsolete nature of much of the engineering plant of the country.—*Proc. Iron and Steel Institute*, Sept., 1902.

Probable Existence of a New Carbide of Iron.

A PAPER contributed to the Iron and Steel Institute by Messrs. E. D. Campbell and M. B. Kennedy, describes an investigation undertaken by the writers for the purpose of deciding the question as to whether a carbide crystallising, or precipitating from solid solution in the presence of a much larger proportion of carbon than is usually found in ordinary steels, might not have a composition differing from that of carbide separating from solid solution in the presence of a very large excess of iron, and of which Fe_3C is the accepted empirical formula. For the purpose of the investigation the carbide was isolated from a sample of annealed white iron. The first result to be noted is that the average composition of the carbide recovered varied from 6·52 carbon and 94·46 iron to 9·45 carbon and 89·40 iron, with an average percentage of 8·20 carbon. Some samples of carbide were afterwards separated by means of a 200-mesh sieve into two portions, coarse and fine, and these were analysed, with the result that the coarse samples showed an average percentage of 7·73 carbon, and the fine samples 9·32 carbon. In the samples containing the highest percentage of carbon, decomposition by acid used in the process of recovery did not seem to have occurred to any greater extent than in the samples with the lower percentage of carbon. This is taken to prove that the carbon in these carbides is chemically combined, and not mechanically mixed as carbonaceous matter resulting from chemical decomposition. Pure carbide of iron (Fe_3C) contains 6·67 per cent. carbon, while a carbide (Fe_2C) would contain 9·67 per cent., and it is pointed out that the ascertained carbon percentages range between that of Fe_3C and of Fe_2C. As it is less likely that iron would form a large number of carbides, with varying percentages of carbon, than that it would form two definite carbides, Fe_3C and Fe_2C, the belief is expressed that the results obtained definitely point to the existence of the new carbide denoted by the latter formula.—*Proc. Iron and Steel Inst.*, Sept., 1902.

Explosion of Steam Boilers.

IN opening a discussion on this subject at a meeting of the Birmingham Association of Mechanical Engineers, Mr. J. Batey emphasised the necessity of careful detailed examination in addition to the usual hydraulic test of a steam generator, and pointed out the difficulty of explaining the exact origin of many explosions. In many cases proof had been afforded that the weakest part of a boiler did not first give way, leading the author to the conclusion that local pressure much beyond the normal must have been existent within the region of the ruptured part. In other words, there must have been an amount of concentrated energy in one part prior to explosion. The author admits the debatable nature of his theory, which assumes the liberation of free hydrogen from the water, and its subsequent violent combination with oxygen. The resulting boiler explosion is said to be brought about by a "sudden augmentation of pressure, concentrated like a blow from a mass, which suddenly compresses the steam, and immediately the pressure is relaxed an enormous augmentation again takes place upon expansion. The whole series of compressions and expansions are to all intents and purposes violent blows of force greater than the ultimate breaking strain of the material of the boiler." The safeguards proposed are the proper location of heating surfaces, so that heat shall be equally distributed, and perfect circulation of the water. The stages of an explosion are three :—(1) initial rupture, (2) enlargement of the orifice immediately after, and (3) the final outburst of reserve steam and water. It is impossible to prevent injury to persons and property near to a boiler at the time of explosion, but in the case of steam-pipes, serious consequences arising from the two latter stages of an explosion may be eliminated by suitable automatic valves, which may also be used to prevent the explosion of one boiler from causing other connected boilers to explode.

An automatic isolating valve is then described, and the author thinks its general use would result in minimising the disastrous effects of the many serious accidents which occur in confined spaces when steam pipes and other boiler accessories are ruptured.—*Reprint by the Birmingham Association of Mechanical Engineers.*

The Consistency of Concrete.

In a paper read before a meeting of the Western Society of Engineers, at Chicago, Mr. H. W. Parkhurst presented the results of experiments relating to the best consistency for concrete. The concrete was mixed in the following proportions: Portland cement, 1 part; sand, 2 parts; gravel, 2·5 parts; crushed stone, 2·5 parts, and the volume of water in the three mixtures made was as follows: dry, 0·41 parts; medium, 0·60 parts; wet, 0·76 parts. The concrete was mixed by hand on a platform, and three blocks were made by shovelling the mixture into boxes, made ready near the platform, and the whole was tamped in layers 6 ins. thick, as shovelled in. The dry mixture took about 25 mins. to put into the box, and no amount of ramming would bring water to the surface. The medium mixture was boxed in 21 mins., and although the top of each layer was flushed by the tamping, the mass was always hard. In the wet mixture, which took 23 mins. to fill into the box, the mass quaked easily, and the men could not stand on the top to ram it. After being exposed to sun, rain and snow for ten months the blocks were broken up, when it was found that the texture of the wet and medium blocks was excellent, and that of the dry block was poor. From his experiments, Mr. Parkhurst draws the conclusion that a medium concrete, or one that has not enough surplus water to produce quaking, while enough to permit easy and thorough ramming is the most desirable. The gist of the paper is found in the sentence: "It is of the utmost importance that concrete shall be consolidated thoroughly by ramming." If it is very wet, ramming cannot be properly performed, and if too dry, no amount of ramming will fill the voids, so as to make a homogeneous mass.—*Journal of the Western Society of Engineers*, Chicago, June, 1902.

New Method of Making Armour Plate.

A recent invention for the super-carbonisation, or face-hardening, of armour plate is described by *The Scientific American*. The new process, proposed by Lieut. Cleland Davis, of the U.S.A. Navy, is said to mark a great advance upon the Harvey and Krupp systems. It includes the substitution of electrical currents for the heat of the gas-fired furnace, and the direction of these currents against the face of the armour plate, while it is in a heated condition, by means of massive carbon anodes, in form not unlike the carbon used in arc lights, but of vastly greater size. During his course of experiments, Lieut. Davis found that if a current of electricity were sent from a carbon into the surface of a plate, it carried with it a certain amount of the carbon and implanted it within the body of the metal. The depth of the hardening is determined by the period of time during which the current is applied, and it is claimed that not only is the surface thus treated harder than that treated by the Krupp process, but the depth to which the hardening is carried is increased. The economy of the process may be judged from the statement that while the Krupp plate is kept in the soaking pits at a red heat for from fifteen to twenty days, the same amount of impregnation with carbon is obtained with the Davis process in five hours. The experimental plate was made at the works of the Bethlehem Steel Company. A moderate thickness, five inches, was chosen, and the only complaint made against the quality of the plate was that the hardening of the face was not uniform, a fault which is attributed by the inventor and makers entirely to the experimental nature of the electrical appliances employed, and not to any inherent defect in the process. In the next plate that is fabricated, carbon rollers are to be substituted for the present anodes, and with these it is expected that a uniform depth and hardness of carbonising will be secured. It is estimated by Lieut. Davis that, as compared with Krupp plate of equal resistance, the new system will produce plates from 20 to 30 per cent. lighter in weight. Further developments of this process will be watched with the greatest interest, and should it prove possible to secure these remarkable results on a commercial scale, the effect upon warship construction will be more radical than anything that has happened in the naval and coast defence world for many years. It is possible that in the new plate the navy has made answer to the new army high-explosive shell.—*Scientific American*, Aug. 16th, 1902.

The Sydney Swing Bridge.

In the *Journal of the Society of Arts*, Mr. John Plummer describes the new bridge recently completed at Sydney. What London Bridge, with its many historic associations, is to London, Pyrmont Bridge is to the capital of New South Wales, each

uniting a couple of densely-populated shores, separated by a wide expanse of water; the River Thames in the one instance, and by a broad arm of Sydney Harbour in the other. Previous to 1857 communication between the two Sydney shores was conducted by means of ferry and row boats, but in that year a wooden bridge, constructed by private enterprise, at a cost of £75,009, was opened, a toll being levied on each passenger, vehicle, or animal crossing. There was a swing span in the centre, to enable masted vessels to pass through, the lowness of the bridge proving a barrier to the passage otherwise of even small steamers, the result being that the stream of bridge traffic was continually being interrupted to allow the swing span, worked by mechanical power, being used. In 1884, the bridge was purchased for the sum of £40,000 by the State Government, and the tolls abolished. This was followed by such a rapid expansion of passenger and vehicular traffic that a new bridge became indispensable; and, after various preliminaries, competitive designs were invited from various parts of the world, that obtaining the first premium being estimated to involve a cost of £295,700. Ultimately it was arranged that the new bridge should be constructed from the designs prepared by Mr. Percy Allan, M.Inst.C.E., one of the engineers in the State Department of Public Works, and an Australian by birth; a commencement being made with the actual work in September, 1899, and the structure formally opened on June 28, 1902, by Sir Harry Rawson, the State Governor, assisted by the Hon. E. W. O'Sullivan, State Minister for Public Works. The new bridge is one of the largest and most substantial yet constructed in the Commonwealth, and the experience gained during the progress of the work will naturally be utilised in connection with the proposed construction of the immense bridge across Sydney Harbour. The total length of the Pyrmont Bridge and its approaches is 1,758 ft., the bridging occupying 1,200 ft., of which 223 ft. represent the length of the swing span. The area of the latter, 12,000 superficial ft., compares favourably with the 10,600 ft. of the Newcastle-on-Tyne bridge swing, the 9,400 ft. of the swing bridge in connection with the Manchester Ship Canal, and the 8,700 ft. of the bridge swing at Hawarden. There may be larger bridge swings in the United States, but none constructed in a manner more up to date than that at Pyrmont. The heaviest work was in connection with the sinking of the caisson forming the main support of the bridge swing. This huge chamber, having a diameter of 42 ft., was commenced on August 2, 1900, and a few weeks later was completed sufficiently to permit of its being grounded, by means of girders and wedges, in the position it was intended to permanently occupy. Then it was gradually worked down a depth of 46 ft. below low-water mark, at which point the cutting edge touched rock on one side. The necessary damming having been completed, the water was pumped out and excavations carried on in the "dry" until a "blow" occurred, when the work had to be continued with the surface of the rock under water. The caisson, when the work of sinking had been completed, was filled with a solid mass of stone and concrete, representing a dead weight of over 6,800 tons. Electricity supplies the motive power for working the bridge swing; its slewing, the lifting of the ends, the operating of the gates closing the traffic, and the lighting of the roadway being controlled by a man stationed in a conning tower on the centre of the bridge. So perfect are the arrangements that by simply pressing a button the bridge —weighing 800 tons—can be opened or closed in 44 secs. Both the slewing and lift motors are carried on a platform inside the drum, the former working through a train of gears a vertical shaft, on the lower end of which is a cast steel rack secured to the top of a pivot pier, while the end lift is effected by means of cones on horizontal shafts, worked by a 35 horse-power motor gearing on to a longitudinal shaft running the whole length of the bridge span. The materials used in the latter were iron and stone, Australian hardwood being largely employed in the construction of the other spans, twelve in number, each having a length of 82 ft.; while the roadway, which is 4 ft. wider than that of the Tower Bridge, London, is asphalted. The estimated cost of the structure, which possesses a substantial, yet not ungraceful, appearance, is £112,000, against £295,700, the estimated cost of the design obtaining the first premium in the competition open to the world, although the necessary works were on a more extended scale.—*Journal of the Society of Arts.*

Gas or Steam for Small Power Stations.

In a report to the Town Council of Dumfries, as to the best method of supplying the burgh with electricity, Prof. D. S. Capper, M.Inst.C.E., deals at length with the comparative advantages of producer gas and steam. He points out that in large Mond plants, the methods of working are such that the ammonia liquor lost in the earlier forms of producer is saved,

and this being a valuable by-product, its sale reduces considerably the cost of gasifying the fuel. The Mond process therefore stands out conspicuously as one that is likely, by its reduction in the cost of running large gas engines, to overbalance the universally admitted practical difficulties in applying such engines to rapidly and widely fluctuating loads. On plants of a smaller size than about 1,000 h.p. it has been found that it is not remunerative to attempt to recover the ammonia. As with other producer plants, such as the Dowson or its modifications by Duff and others, so with the Mond plant when below about 500 h.p., the difficulty of obtaining a uniform quality of gas with widely varying loads is great, and this counter-balances, to a considerable extent, the benefits of the high thermal efficiency of the modern gas engine. With all gas engines, if a load which exceeds by 10 per cent. the normal working load of the engine is suddenly thrown upon it, the engine is liable to suddenly stop, and thus to throw an extra load upon other engines working in parallel with it, causing them to stop in turn, thus throwing the whole station into confusion and the town into darkness. It is essential, therefore, that with a gas engine, a larger engine than is required for normal average working should be coupled to each electric generator. This adds considerably to capital expenditure, and at the same time increases the working cost, owing to the fact that the engines are working for the greater part of their time at a low load, and therefore low efficiency with accompanying irregularity of speed. From these considerations it follows that the undoubted thermal efficiency of the gas engine can only effectively be taken advantage of in the case of large plants working on a load not liable to rapid fluctuation. A further practical consideration connected with the gas engines is this:—Gas engines of moderate size, and still more of large size, have hitherto only been constructed to work at a speed low compared with that of steam engines. It follows, either that belts or gearing must be put between the engine and the electric generator, or that a generator, large, and therefore costly, compared to the power which it gives out, must be used. In the former case, the inevitable losses in gearing of the most efficient kind cause a considerable increase in the annual working costs; or, in the second case, the capital expenditure must be proportionately increased. The Report further states that the adoption of belt- or gear-driven dynamos, except in special cases, is a retrograde and inadvisable step, and that there is no probability that within a reasonable time gas plant of the limited size required at Dumfries for the first few years is likely to be introduced, which for practical working will equal or in economy so surpass a steam plant as to warrant its experimental use in the burgh. For larger powers than are likely to be required at Dumfries, Professor Capper considers the full benefits of the Mond producer could be obtained, and the disadvantages of fluctuation in load would be diminished by spreading the load over a number of different units. For the purpose of comparison, balance-sheets are added, showing that practically no difference is to be anticipated between the annual cost with gas plant and with steam, but that while a steam plant for lighting, plus tramways, including permanent way, cables, etc., from the railway station to Glenaple would cost £37,500, a gas plant of the same extent would cost £39,150.

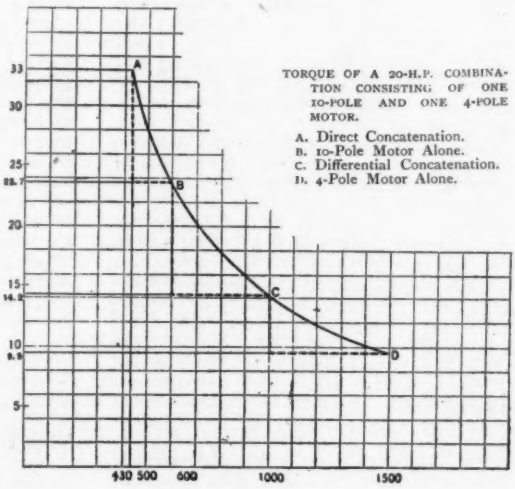
The Storage of Steam Coal.

THE result of an experiment bearing upon the effective storage of steam coal is stated in the *Times* by Mr. Macaulay, General Manager of the Alexandra Docks and Railway, Newport. He says:—"In shipping coal an occasional lump falls into the dock. This, with mud and dust also settling to the bottom, is periodically dredged. The coal thus recovered, after lying three or six months under water, burns well. It struck me, noting this work going on at the time that Lord Charles Beresford was bewailing the serious loss of calorific power in the method of storage of steam coal obtaining at our naval bases, that it might be practicable to store coal to greater advantage under water. The possibility was suggested that the volatile constituents that make South Wales coal so valuable might be preserved from dissipation by being confined under water—much like gas in a gasometer—and also that the friable solid constituents would be protected by the same means from the disintegrating and oxidising effects of the air. Going further into the matter, I had an experimental quantity of coal placed under sea water in a suitable vessel and special manner for two months. At the end of that time an estimation was made of its calorific power, and compared with one made of that of the coal before immersion, the two quantities experimented upon being carefully taken from the same block of a typical sample of Monmouthshire steam coal. The loss was less than 1 per cent., or to be quite correct ·8075. This, I admit, appears very small, and the selection of coal may have been exceptional, but the result is certainly experimentally correct. Even if far larger, it would

compare very favourably with the loss of power arising from the present method of storing. There are, I understand, no available figures at the Admiralty of the amount of this loss ; but Lord Charles Beresford has stated that, in his experience, a vessel would have to consume more than twice the normal amount of coal per indicated horse-power, if the coal had been kept too long in store." The idea is at least worth trial on a suitable scale, especially as similar results were obtained some years ago by Admiral Lloyd, in burning coal that had been under sea water for nine months. Mr. Macaulay suggests that a concrete tank, to hold, say, 5,000 tons, would not be very expensive to construct—we have loaded single vessels with double that amount—the sea water to cover the coal would cost nothing, it could be readily run off when the coal was needed; and exposure to the sub-tropical heat of Malta or Gibraltar would be sufficient to dry it for use in a very short time. If the experiment did not prove a success, the tank might find ready use for water storage.

Polyphase Motors for Traction.

In a paper presented at the annual meeting of the American Institute of Electrical Engineers, Mr. Ernst Danielson deals with an arrangement rendering it possible to obtain, economically, four different speeds by means of only two alternate current motors ; a device that ought to remove the difficulties now attending the application of polyphase motors to railway work. After pointing out that the concatenated combination of two similar motors results in a speed corresponding to one-half the regular speed of each, and an output that is only half of the output of the motors operating independently, he shows that when two motors of different speeds, *i.e.*, with a different number of poles, are combined in a concatenated connection, a speed is obtained which corresponds to a number of poles equal to the sum of the two motors. Further, three speeds are possible : the speed of one motor alone, the other running idle ; the speed of the other, the first running idle ; and the combination speed. But another step may be made, for in connecting the concatenation the leads may be crossed so as to get a resultant torque which is the difference between those of the two motors. The last arrangement is termed a differential concatenated connection. In order to see the result of this, let us take two motors, one with 10 poles and one with 4 poles, both of the same output, say, 50 h.p. each, the rotors of which are mounted on the same shaft. If now the source of electricity be connected to the stator of the 4-pole motor, and the rotor winding of the same motor be connected to the rotor winding of the 10-pole motor in such a way that the magnetic field in both rotors will revolve in the same direction relatively to their cores—then the torques of both motors will be opposite to each other. As both motors have the same output, then if the torque of the



TORQUE OF A 20-H.P. COMBINATION CONSISTING OF ONE 10-POLE AND ONE 4-POLE MOTOR.

A. Direct Concatenation.
B. 10-Pole Motor Alone.
C. Differential Concatenation.
D. 4-Pole Motor Alone.

4-pole motor be called unity, that of the 10-pole motor will be 2·5 ; accordingly the resulting torque in this case will be 2·5 − 1 = 1·5 and acting in the same direction as that of the 10-pole motor. As the system begins to move, the frequency in the circuit belonging to the rotors increases, whereas the frequency in the stator of the 10-pole motor decreases. Started in the regular way by inserting resistance in the last secondary and gradually cutting it out, the speed comes up until the frequency in the stator winding of the 10-pole motor approaches zero, which will happen when the speed is 1,000 revolutions per minute (the frequency assumed at 50 cycles per second), that is to say, we have obtained a motor running at 1,000 revolutions and with a

RELATIVE AMOUNT OF ENERGY CONSUMED.

	Accelerating only.		Accelerating and Electrically Braking.	
	Without gearing.	With gearing.	Without gearing.	With gearing.
D. C. Motor, resistance entirely cut out at $\frac{3}{4}$ full speed	1.33	1.4	1.33	1.4
D. C. Motor, resistance entirely cut out at $\frac{1}{2}$ full speed	1.4	1.48	1.4	1.48
A. C. Motor, simple.....	2.17	2.29	2.17	2.29
A. C. Motors regular concatenated connection.....	1.68	1.77	1.36	1.47
A. C. Motors, three speeds: 0.4 : 0.67 : 1.....	1.5	1.58	1.17	1.27
A. C. Motors, four speeds: 0.285 : 0.4 : 0.67 : 1.....	1.45	1.52	1.15	1.24

torque which is represented by 1.5; the torque of the 4-pole motor of 50 h.p. running at 1,500 revolutions being equal to 1. Accordingly the horse-power of this arrangement is still 50. By means of the combination of two motors the same output is thus obtained under the following conditions:—(1) the 4-pole motor alone, the 10-pole motor running idle, speed = 1,500 revolutions per minute; (2) differential concatenation, speed = 1,000 revolutions per minute; (3) 10-pole motor alone, 4-pole motor running idle, speed = 600 revolutions per minute; (4) regular or direct concatenation, speed = 428 revolutions per minute. These torques and speed are graphically represented in the diagram on p. 355, where the torque is given for any of the speeds with regular full load current on a 20 h.p. motor, without consideration of the lag, which, of course, is greater in the concatenated connection—direct or differential—than with one motor alone. If gearing be used, the motors need not have different numbers of poles, but in that case the loss therein should be taken into consideration. This loss may generally be estimated at about five per cent. It must, however, be borne in mind that in the case of differential concatenation it may amount to somewhat more, since the power transmitted through the gearing really is more than the resultant power. In the table above, where the results are brought together, this increased loss is neglected. The table gives a comparison of the different systems as to input, the motors connected for starting up to full speed and electrically braking down as far as possible. Admitting that the polyphase motor as a rule is fully as efficient as the series D. C. motor, it may be considered that when working on an even road the difference in energy consumption will be negligible, then it would appear that by using the four-speed arrangements of concatenated connection it would be possible to get a more economical method of working electric roads than by means of the D. C. system with series motors. Considering at the same time that for greater distances the electric energy has to be generated as alternating current and then transformed into direct in converter stations, whereas with polyphase motors on the cars simply static transformers can be used giving a difference in loss of at least five per cent. to seven per cent. in favour of the alternating current motors, the comparison comes out still more in favour of these. An advantage also for them is that there is no need for high voltage in the rotating parts of the motors; the rotor windings may be arranged for any desired voltage, thus giving the designer full liberty to choose this so as to get the most convenient winding. The author is fully aware of the drawbacks inherent to the alternating system, but arrives at the conclusion that in many cases its disadvantages will probably be more than balanced by greater economy.—*Proc. Am. Inst. Electrical Engineers*, May, 1902.

Unit Stresses in Flexure.

As met in practice, flexure most frequently occurs in the case when the neutral axis is normal to the plane of the load, but it should be recognised that this, although a simple case, is at the same time a special one. This point is emphasised by Prof. L. J. Johnson, in the course of a paper lately read before the Boston Society of Civil Engineers, and it is stated that while the determination of unit stresses for this case is commonly treated in standard works on resistance of materials, the fact that it is a special case is rarely pointed out, while other cases are usually ignored. The result of such treatment must naturally be that methods of computation, valid for general cases, are insufficiently known, so that the simple formula for the special case mentioned is often wrongly applied. The paper to which we now refer is intended to direct more general attention to methods by which the distribution of stress can be determined for any case of flexure in a straight bar, when the elastic limit is not overstepped. Although

the subject is of as much importance from the point of view of abstract science as from that of practice, a special effort has been made by the author to meet the needs of practising engineers. Briefly stated, the scope of the paper includes the consideration of problems relating to the design of purlins; the proportioning of unsymmetrical sections, such as angles and Z-bars, subject to transverse load; and the investigation of eccentrically loaded columns, including such as are commonly used in riveted truss work. All results given are strict mathematical deductions from the generally accepted hypothesis that the unit stress at any point in a moderately bent beam is proportional to the distance of that point from the neutral axis.—*Journal of the Association of Engineering Societies*, May, 1902.

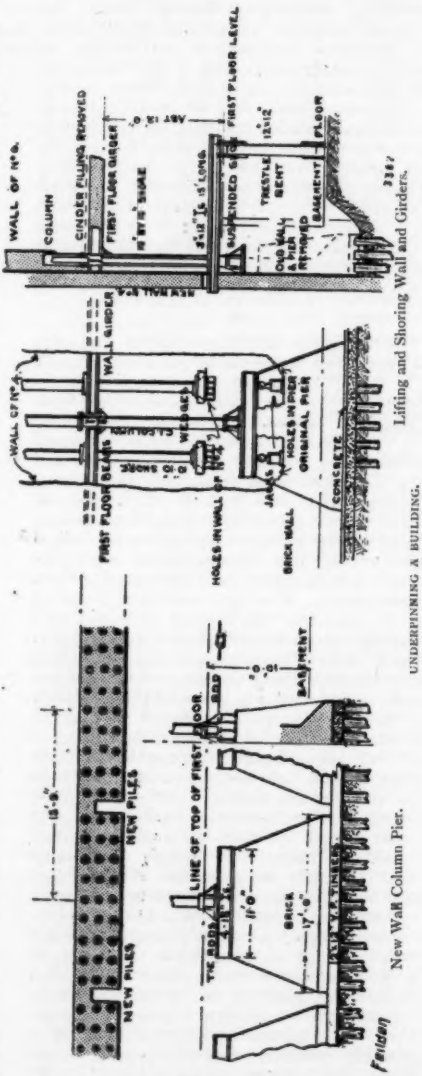
Refuse Destructor Clinker.

In the course of a paper by Mr. F. Leslie Watson, read before the recent Public Heath Congress, reference was made to the utilisation of clinker from refuse destructors. For crushing, a mill introduced and patented by the late Mr. McTaggart and Mr. Cox, has been used with satisfactory results. The mill consists of a pair of fluted rollers, cast with a chilled face, geared together and driven by strong double helical spur-wheels, the rollers having a special elastic attachment to their spindles to prevent undue shock. Crushed material is taken up by a chain belt elevatorand delivered into a revolving screen, which divides it up into four or more different sizes as required. The crushed clinker may now be used for concrete making or plastering, according to size, and in many instances it is found that in its crushed and graded condition the clinker is an extremely saleable article without further manipulation. A very important machine for utilising the clinker is the mortar mill. Owing to the extreme hardness of the material with which it has to deal, the mill should be much more strongly constructed than is usually the case, and should weigh half as much again as the ordinary mortar mill used for builder's work. For the manufacture of flags, further machines are required, and, although in successful operation in quite a number of towns, the first cost of a flag-making plant is so heavy that many corporations are deterred from the investment. A flag-making plant consists of a grinding machine—for which purpose the mortar mill answers very well—in which the clinker is crushed very fine and mixed with a due proportion of cement and water, afterwards passing, in a semi-fluid state, into the moulds of a hydraulic flag press. The pressed flags are carefully stacked in racks, which prevent warping and twisting while drying. A steam drying chamber is a useful adjunct to a flag plant, as the seasoning—which ordinarily takes weeks—may then be effected in forty-eight hours. The process of manufacturing bricks from crushed material has been more highly developed on the Continent than here. An excellent system is that introduced by Dr. Schulthess, of Zurich, where a complete plant is in successful operation. Tests of the crushing strength of bricks manufactured at Zurich show that they are superior in strength to good clay bricks. A special feature about the Schulthess system is that common lime may be used, and that the proportioning and mixing of the materials is so thoroughly carried out that the best possible results are obtained. The plant consists of a lime-slaking machine, in which the slaking is effected by means of a small quantity of moisture, and by the aid of low-pressure steam. Thus excess of water is avoided, and the hydrated lime is obtained as a dry powder. The slaked lime is delivered by a conveyor to a screen, where any foreign matter is rejected; and from thence into a dividing machine, where the proportioning of lime and clinker is effected. Thence the materials pass to a mixing machine, where the exact quantity of water is introduced to give them the necessary plasticity, and the moulding process is carried out by a power press similar to that used in making clay bricks. The formed bricks are conveyed to the steaming chambers, where they are subjected to the action of saturated steam at atmospheric pressure during about forty-eight hours, after which period they can be taken out completely seasoned and ready for use.—*The Surveyor*, Sept. 5th, 1902.

Underpinning an Unfinished Steel-Cage Building.

The following is an account of an interesting operation that was carried out in connection with the restoration to a safe condition of an eight-storey cage-building which, during the course of construction, was considerably damaged through settlement taking place and other causes. We are indebted for the details to the *Engineering Record* of New York. The building, which is situated in East Eighteenth Street, New York, has a 200 by 100-ft. U-shaped plan, with two wings about 25 ft. wide, 50 ft. apart in the clear, and 100 ft. long; these wings have street fronts, enclose an old building, and are connected together by the transverse main part of the building.

The walls, floors, and roofs are supported on cast-iron columns which, for the main walls, were built into the brickwork, and terminated at the first floor level. They were seated with cast-iron pedestals on grillages of longitudinal I-beams, which distributed their loads over brick buttresses, racked out from the inner faces of the wall, and seated on concrete footings on the tops of groups of piles. In the west wall, the columns were from 10 ft. to 18 ft. 9 ins. apart, and the 24-in. brick wall between them was carried on a concrete footing laid on the surface of the ground, about 13 ft. below the curb, without piles underneath. The basement was about 12 ft. deep, with a concrete floor above the ground-water line, and it was believed that the soil consisted of earth, sand, and quicksand to the hard-pan, about 25 ft. lower down. After the erection of the framework of this building had been commenced the adjacent building on the west side was torn down and the construction was commenced there of a tall new building. An excavation was made there nearly to the water line, about 15 ft. below the curb, and the foundations were carried down to hard-pan. Soon after this work was commenced, the west wall of the building under consideration began to lean to the west, and became dangerously out of plumb. It settled 5 ins. and moved transversely 17 ins. at the top, about 100 ft. above the ground, pulling all the columns in that wing out of plumb and cracking the masonry walls, which were of red brick in the side, and in front were of sandstone for the two first storeys and of terra-cotta and white brick above. The building was so much damaged that it was considered unsafe, and it was decided to tear that wing down completely. A proposition was made by a well-known construction company to restore it to a safe condition, to plumb the walls and framework, and to rebuild the foundation, and a contract was subsequently awarded them. At each of the six columns nearest the street in the west wall, holes were cut partly through the offset brickwork in the piers, and jack screws were set under both ends of the grillage beams. In the four lower storeys the brickwork was cut away from the columns, and, just above the first floor level, holes were cut through the side wall of the adjacent building on each side of each column. In each hole one end of a set of three 12-in. I-beams, about 15 ft. long, was set, with a bearing on the brickwork. The other ends of each set of beams were supported on the cap of a framed trestle bent parallel to the wall, with its sill on the basement floor. The jacks were screwed up, and lifted the column bases about 5 ins. clear of the grillage beams on the piers, shearing through the uncut parts



of the brick wall in the upper storeys. Pairs of vertical wooden shores were set under the

ends of the wall girders in the second, third, fourth and fifth storeys to take their loads from the columns. The wall girders in the upper storeys were allowed to transmit their loads directly to the columns. The transverse floor girders at each storey remained seated on their column connections without additional support. The upper shores were 6 ins. by 8 ins., the next 8 ins. by 8 ins., and the two next 10 ins. by 10 ins., all being in the same vertical lines, and all being wedged at the bottom. The lowest ones were seated on cross pieces over each set of needle beams, and, the wedges being driven to a solid bearing, the jacks were slacked off and left the lower sections of the columns hanging free above their original supports. The four upper storeys were carried in the usual way, as designed, by the columns, and were suspended at the fourth floor from the connections there with the wall girders, the loads being transmitted thence through the shores, only one storey of column weight and transverse girder load being transmitted through any single one of the lower wall-girder connections. The grillages and piers were removed and all the old side and front walls taken down. The concrete was removed from the tops of the piles and from between the piers, and the old piles, some of which were found to be very small, were driven a little deeper by an ordinary pile driver with a follower, and new piles are being driven between the piers so as to make three continuous rows from front to rear of the building under the whole length of the wall, as far as it required straightening and had been torn down, a length of about 90 ft., the full length of the side of the adjacent excavation. These piles are to be capped with a solid row of longitudinal 12-in by 12-in. range-timbers, blind-spiked together sideways, and seated just below ground-water line. On this grillage the new walls and piers, with an offset brick footing, will be built up as shown in the detail; the old grillage beams will be set closer together on the piers, bolted together with shorter separators, filled with concrete, and the column pedestals will be seated on them at the required level to plumb the building, the framework being straightened up after the columns are permanently seated.

The Railroads of the World.

THE *Archiv für Eisenbahnwesen*, which has now for many years published statistics of mileage of the railroads of all countries in the world, with some other data, says the *Railroad Gazette*, gives a somewhat more extended review in its last number, in which the figures are brought up to 1900, and so make a record of the work of the last century. The mileage built in each decade has been for the world:

1830–40	4,772
1840–50	19,198
1850–60	43,160
1860–70	63,255
1870–80	101,081
1880–90	152,179
1890–1900	107,421

The mileage built before 1830, insignificant in amount, is included with the 4,772 miles credited above to the decade, 1830-40.

Of the total of 491,066 miles completed at the end of the century, more than one-half has been built since 1880, and nearly three-fourths since 1870. The total built in the forty years down to 1870 (130,385 miles) was one-seventh less than the construction in the single decade ending with 1890. It is noticeable, however, that in the last decade of the century 44,758 miles less were built than in the preceding ten years. This is one of the indications that the civilised and productive industrial countries of the world are now generally well equipped with these instruments of transportation. Europe (except Russia) and North America have immediate need of no large additions to their mileage. There is still abundant room for railroads in Asia, Africa, and South America, but the slow growth of industries on these continents, two of which are over rather than under populated, but whose population is to a great extent a bar to progress such as Europe and North America have had in the past century, gives no promise of rapid railroad extension.

Foundry Cupolas.

By J. R. KELLY.

ALTHOUGH much has been written on this subject by experienced writers from time to time, it is still a matter of considerable doubt amongst foundry managers as to what type of cupola is the best for their own particular work. At the present time, a few unbiased remarks may be of service.

From a careful observation of a large number of foundry cupolas in this country, the writer has found a remarkable state of affairs in existence, each foundry-man seeming to have some arrangement differing from his fellows, either in the number of the tuyères, the shape, position, and area of same, the advantages and otherwise of a drop-bottom or a receiver, and last, but not least, the great variety of opinion as to the best method of providing an efficient blast—by a fan, or one of the numerous types of positive blowers at present on the market. Even in shops doing a similar class of work and situated in the same district, much difference of opinion is found, one manager saying, "My coke consumption is too much, 5½ cwt. to a ton of iron, while So-and-so, who melts about the same weight of metal per week, uses only 2½ cwt." When the matter is gone into, one is found to have a cupola altogether unsuitable for his melt, diameter far too large, tuyères badly arranged, being far too high from the bottom, and entailing considerable more "bed" to bring down the quantity of metal required, while the other has a cupola of suitable diameter, properly proportioned areas of tuyères, together with a sufficient pressure and quantity of blast. Of course, the user of a large diameter of cupola, melting, say, 20 to 30 tons per day or more, can get a much better ratio of coke consumption than the small user who melts perhaps 4 or 5 tons each "blow," the smaller diameter cupola requiring more coke for the "bed" in proportion to the quantity of iron melted. It is scarcely fair to compare the results obtained, as to fuel consumption, from different cupolas, without carefully comparing the particular circumstances of each case, such as the nature of the work, the quality of the coke, the proportion of scrap and pig used, together with the average daily "melt," also the method of charging the cupola while in "blast." A careless "blast tenter" can run up the coke bill in a wonderfully short space of time. Two cases illustrating this recently came under the writer's notice: the first one was a large textile machinery works, which has long ago dropped the old-time method of leaving the cupola in the hands of the "tenter" with unlimited coke, the only thing asked from him being to get the metal down quickly. The cupola at these works is fed, when in blast, by a chain conveyor, each bucket of which contains a known quantity of coke. The scrap is weighed in heaps on the ground level, before commencing operations. The foundry foreman gives his instructions to the "tenter" according to the quantity and quality of metal required for the day's melt—so many pounds of scrap and pig, with a certain number of buckets of coke as his past experience had proved to give the most economical results. All went well, the coke used per ton of iron melted being reduced to a minimum, until one day a careless man was placed in charge of the cupola: he received the usual instructions, and all seemed in order until the fourth day, when the coke ran out; the foundry manager was astounded—a week's supply of coke gone in four days! On reckoning up the weight of iron melted, that was found to be right. The "tenter" was carefully watched next "blow": instead of following out instructions given him, the man simply sent up to the charging-door coke, pig, or scrap, indiscriminately! The second case was a well-known firm of engineers in the North, making general castings. The proprietor, having carefully studied the costs of the foundry, recently erected a large new cupola, and endeavoured to reduce the cost of melting his iron by every means possible; everything was checked and weighed, and the results obtained, when the "tenter" was personally directed, were brought down to 2 to 2½ cwt. of coke per ton of iron melted However, the average consumption was not maintained. Another furnace-man was procured—still the same result; a further change was made without much difference, and the proprietor, in despair, decided to have no more so-called qualified cupola tenters, who consider they know by experience. He took a man altogether strange to

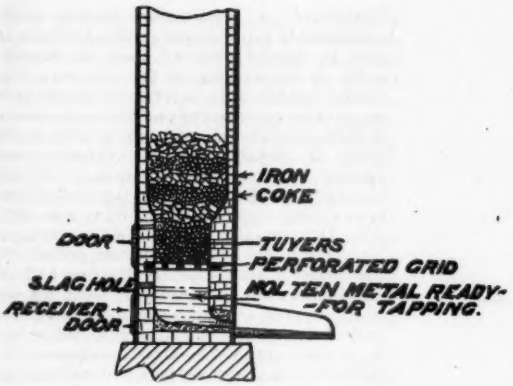


FIG. 1.

a cupola, carefully instructed and supervised him, and in the course of a month the coke ratio was brought to the test level. The foregoing cases show that, no matter what make or style of cupola is used, unless it is properly worked, with all coke and iron weighed, no economy can be expected. Many foundries are working with a ratio of 4 or 5 to 1 in coke consumption, and even worse than that, simply through neglecting to bring the same care and thought expended on other departments to bear on the foundry cupola and the way it is charged.

Many attempts to design a foundry cupola with some special features above the ordinary type have been made, so far with no great degree of success. A reference to the Patent Office files shows that inventors have constantly been at work. An early type of cupola, which promised well, but, I believe, proved an utter failure, was made by Mr. Peter Newlands, of Ashton-on-Tyne, in the year 1869. A grid or perforated platform (see Fig. 1) was fitted about 3 ins. below the lowest tuyère and 12 to 15 ins. above cupola bottom; the coke rested on this platform, and as the iron was melted it dropped through the grid into the space below, this space acting as a receiver for the molten metal until it was required. Theoretically, this construction was excellent, the heat from the burning coke keeping the molten metal very hot, but in actual working the cupola gave a deal of trouble, the perforations in grid becoming made up with slag, the charge having then to be withdrawn. Two doors were fitted at the back, one above the perforated grid.

A modification of this arrangement is working with every satisfaction at the present time on two cupolas, 36 ins. diameter, in the foundry of a Yorkshire firm. The cupolas are worked alternately day by day, and for several years past have given a good result. The construction of these cupolas is on similar lines to Fig. 1, the difference being that the receiver is covered over with a brick arch instead of the perforated grid. This arch has a 6-in. diameter hole in centre, the metal when melted running down into the receiver underneath, the top side of the brick arch iscovered with clay, and made to slope towards the centre. The great point about this design is in the exceedingly hot metal obtained, the position of the receiver immediately under the cupola proper being responsible for this. The first idea of the writer on seeing these two cupolas was that the coke would drop through the 6-in. hole in the brick arch, and cause an accumulation of slag, etc., in the receiver. This, however, is very small, the slag-hole providing a ready means of removal; in fact, the proprietor stated that no trouble whatever arises from this cause. In this particular case a very strong blast is used, 1 to 1½ lb.

A novel departure in cupola design was introduced on the Continent by Dr. O. Gmelin, in the early eighties, but up to the present has not been adopted to any great extent, the initial cost of construction being in considerable excess above the ordinary type.

Dr. Gmelin used 2 shells, one being about 4 in. smaller in diameter than the other. When secured together the space between the shells was used as a water-jacket, the water being admitted at the base of cupola and circulated round the inner shell, overflowing into a waste-pipe a few inches below the top. The chief point the inventor claimed was the absence of repairs to the inside lining. This was about 1½ in. thick of fireclay, and having a constant flow of water all round, the temperature was kept greatly under the usual amount, thereby retaining the heat better in the melting zone, resulting in greater economy of coke consumption. From the results said to have been taken from actual everyday working, this cupola appears to be as economical as any type, a coke consumption of 1½ cwt. per ton of iron being claimed on a medium melt.

Many attempts have been made to use a steam jet in the form of an injector nozzle at the upper part of the cupola. Mr. Adam

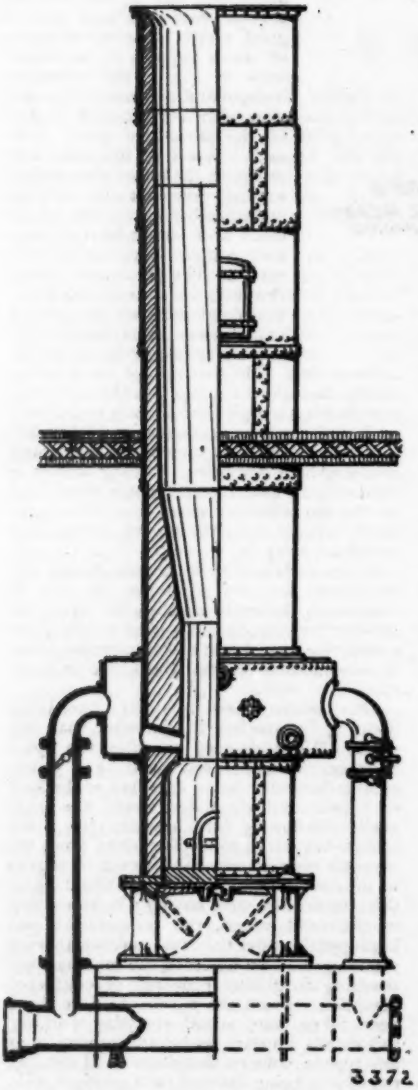


FIG. 2.—ALLDAY'S ELECTRIC CUPOLA.

Woodward, of Manchester, having made considerable experiments in this direction in 1866, the results obtained were satisfactory so far as the melting of the iron was concerned, but the quantity of steam used made the working costs excessive. Some adaptation of this principle was adopted in 1887 at the works of Messrs. Herbertz, Cologne, and appears to have given a good result, the castings turned out being very pure and soft, even when a common brand of pig was used. The Doherty process of melting iron, as introduced into this country at present by the Doherty Iron Casting Process, Ltd., of London, is another method involving the use of steam jets, and from the samples of iron melted by this process shown to the writer, it would appear to have overcome the difficulties in producing pure and soft castings from common grey pig, a piece of cast-iron plate, $\frac{3}{8}$-in. thick, showing no signs of fracture on punching a $\frac{3}{4}$-in. diameter hole through the centre.

One of the best known cupolas is Stewart's Rapid, made by Messrs. Thwaites Bros., of Bradford. In the larger sizes, three rows of tuyères are used, the top row being fitted with plug valves. All tuyères are contained in a deep air-belt, this being divided into two parts, each half having a separate stop-valve to enable the furnace man to shut off one-half the tuyères if any slag trouble arises. The special features in this cupola are the addition of a "Receiver," and the arrangement of the tuyères. This enables the tuyères to be brought within a few inches of the bottom of the cupola, giving a less quantity of coke required for the bed than the ordinary type.

A cupola of somewhat similar design to the above has recently been introduced by Mr. Barrett, of Crosshills, Keighley, and is said to give a good result.

A cupola well known in the Midlands and the North is the Greiner and Erpf Economical Cupola, made by Messrs. J. P. Hornning & Son, Middlesbrough, and, from a theoretical point of view, this arrangement seems to have made an advance on anything previously placed on the market, an attempt being made to consume the carbonic oxide, which to a great extent in the ordinary cupola is burnt above the melting zone, or passes away into the atmosphere. The Greiner and Erpf cupola has the ordinary arrangement of main tuyères and blast belt, one or more rows of tuyères inside belt, according to the diameter of cupola. In addition to these, a number of small diameter tuyères, about ten in number, are carried round the cupola shell in the form of a spiral, as shown on Fig. 5. When the cupola is in operation, the carbonic oxide generated from the charge, say at *A*,

rises until the lowest of the small tuyères acts upon it, causing combustion, at a point where heat is of service, of what would otherwise pass away to the atmosphere, or be turned nearer the top of the cupola, where the heat is of no service in melting the charge. The spiral arrangement of tuyères, extending some distance from the lowest to the highest tuyère, does not allow any great amount of inflammable gases to pass away unconsumed. This type of cupola is one of the most successful, particularly for large melts, one of the largest makers of cast-iron pipes in this country having four in constant operation, giving excellent results, a saving of 20 per cent. in coke consumption being claimed over the ordinary style of cupola.

A cupola giving excellent results in many foundries is the Allday's Electric Cupola shown in Fig. 2. This cupola does not differ materially from the ordinary style with plain tuyères and airbelt: the chief difference is, the tuyères are ten in number in three rows and placed at a slight angle pointing towards the bottom of the cupola, also the firebrick lining is made of smaller thickness below the lowest tuyère, giving a greater area in the well or bed.

On comparing the different cupolas in use in this country it will be seen that the great point of difference is the arrangement and number of the tuyères, every maker claiming his own particular method of construction to be the best. Our American competitors have experimented largely in this direction, but from comparisons of the cupolas now in use in some twenty of the largest iron-foundries in U.S.A., from particulars given in Mr. West's book on foundry work, the general type now used is a straight bore cupola with a reasonable number of tuyères. The Paxson-Collian, the McCormack-Collian, the Newten and the Whiting cupolas, all well-advertised types in the States, are all practically straight bore, and differ very slightly from the original Collian cupola introduced in 1880. The heights and area of tuyères vary a little: one detail which might be of interest is the crank or handle for shutting off the upper row of tuyères when melting smaller quantities of iron than usual or towards the end of the "blow." This arrangement is shown on the elevations given (Figs. 3 and 4) of the Paxson and McCormack cupolas, and is easily within reach of the "blast tenter." Many cupolas I have seen are fitted with a stopping device for each upper tuyère, but the handles are placed on the top of the main blast belt and practically out of reach of the "tenter," with the result that the upper row of tuyères are left open when they ought certainly to be closed, to save the lining when small

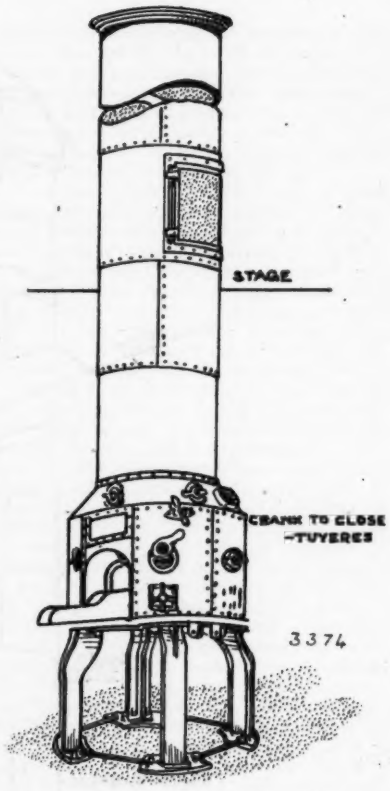


FIG. 3.—MCCORMACK-COLLIAN CUPOLA.

melts are going. The writer has found that many practical men keep to a single row of main tuyères of ample area, solely for the reason that the upper tuyères are so destructive to the lining material, sacrificing the slight gain in increased speed of melting obtained by two rows of tuyères. The saving by adapting a complicated arrangement of smaller tuyères is more than counterbalanced by the greater amount of attention required to keep them in working order. An intelligent "furnace tenter," being somewhat of a *rara avis*, it is the best, in the writer's opinion, for ordinary general ironfounding, to confine oneself to a plain, straightforward type of cupola with a moderate number of tuyères of suitable areas. It will be found that if this is done, the results, if the cupola is properly worked, will not be far below

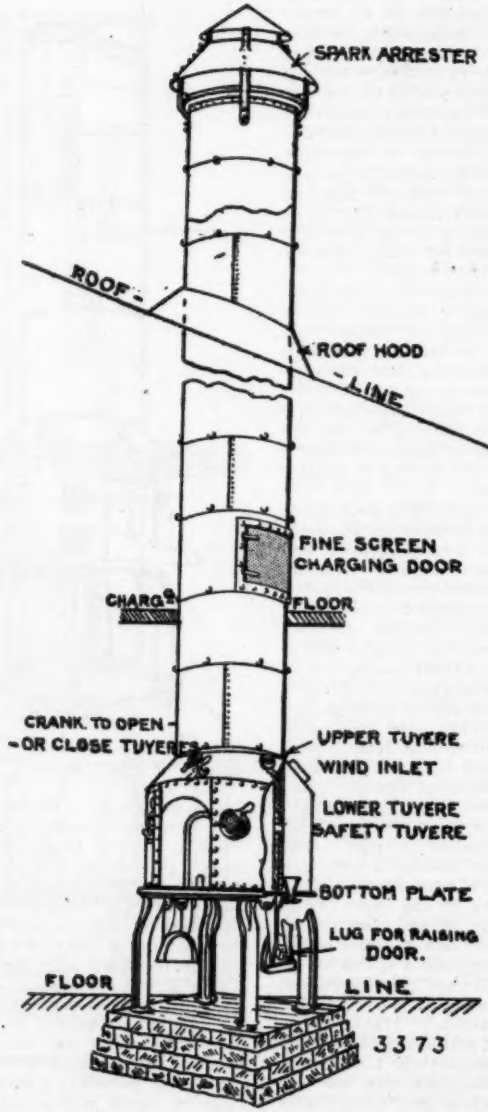


FIG. 4.—PAXSON-COLLIAN CUPOLA.

any of the many styles now on the market; indeed, many of these are in use at foundries, and giving a result in coke consumption considerably above what would be obtained with a simpler form of cupola, solely through the disregard paid by the "furnace tenter" to the, in many instances, rather complicated directions, which must be followed out to get the full benefit of the special arrangement.

For general work, say up to a 20-in. internal diameter, two tuyères are ample; over that an airbelt should be used, with four or even six tuyères; the airbelt may be divided in halves by a plate, each half controlled by a separate shut-off valve, as in the "Rapid" cupola. This will enable the blast to be shut off one-half the tuyères if found necessary. The area of tuyères is another much-disputed point in cupola design: if too small in diameter they are liable to get made up. The average practice taken from data obtained of a number of cupolas in active service, in Lancashire and Yorkshire chiefly, works out at about one-eighth of the area of cupola diameter inside at the tuyère level, divided by the number of tuyères used. This would give a cupola 34 ins. diameter four 6-in. diameter tuyères. In deciding the height of tuyères above the base of cupola, so many different circumstances come under consideration that no rule can be laid down; one founder, perhaps, will take the iron as fast as it is melted, and another may require several tons of iron to be in a fluid state before "tapping out"; the important fact in fixing the height is that the higher the tuyères are placed, the more coke is required for laying the bed. Many ironfounders have made a reduction in their coke consumption by dropping the tuyères nearer the cupola bottom: care must be taken not to overdo this, or possibly some day the metal will overflow down the tuyères. The advocates of a receiver make the most of this point, saying the quantity of coke used for the bed is much less, giving greater economy, also that when a large quantity of metal is required for a large casting, it can be retained in the receiver and tapped as required. Many ironfounders have, however, discarded using a receiver, saying, they only cool the iron, and if a large casting is to be made the ordinary ladle under the tapping spout is practically a receiver; in fact, the writer has seen a large casting for an engine bed, weighing over 10 tons, made successfully from a cupola running about 2½ to 3 tons per hour, care being taken to see the large ladles used were previously heated very hot. Another objection is the time spent in cleaning out a receiver after each melt, double the work being required over the ordinary cupola. Taking everything into consideration, the general ironfounder is well advised to dispense with a receiver altogether. In the States a receiver is very rarely used, the American practice being to run the iron as soon as it is melted.

The drop bottom is now being adopted more generally in this country; although many contend that it is a doubtful advantage, as the risk of trouble occurring is apparent to any observer of the usual method adopted by most furnace-men in dropping the bottom of a cupola: this operation being generally done at the last minute, there is some possibility of an accident. If, however, the "tenter" will see that all the charge possible is run out at the front spout before dropping the bottom, no trouble should be experienced. The drop bottom is universal in America, and as the prejudice found amongst a large number of ironfounders in this country wears down, it will be adopted more generally. It is not advisable to have a drop bottom on cupolas under 24 ins. internal diameter at tuyères, as the extra trouble required in making up the cupola bottom each morning is more than the convenience of removing the charge from these smaller cupolas is worth. Another point in favour of the drop bottom is the great convenience of same when the cupola is undergoing repairs to the firebrick lining, the materials being readily hoisted to position. When designing a drop bottom care should be taken to see that the bolt securing in position is of ample size and readily removed, many a man having been burned when attempting to loosen the bottom. The best method of retaining the drop bottom in place is by means of a vertical bar rising from the floor, this being easily removed. Another point in cupola design is height of the shell, many advocating a longer length than usual. This, again, is a matter for individual decision—so much difference in position, quantity of metal melted, etc., being found in each case, no rule can be fixed; each cupola should be considered separately by the designer, a length of shell suitable for one diameter of cupola in one case being altogether wrong in another.

Cupola working: this is a matter which every manager should thoroughly understand. If he is able to occasionally supervise the method adopted at his own foundry, many things whereby some saving could be made are sure to occur to him. As every pound of coke used should give its proportion of heat in the melting process, care should be exercised in charging. As

previously mentioned, great differences are possible in the quantity of coke consumed per ton of metal, even with the same cupola. It will be readily seen that, if coke is used too sparingly, dull metal will be the consequence, causing a greater percentage of bad castings; by careful consideration for a few days the correct proportion for each individual case will soon be ascertained. When a decision is arrived at, every care should be taken to see that the charge is made in the proportions desired regularly, everything being weighed, so that if a bad result is obtained, some data is available to work from. A point often overlooked is the amount of partially consumed coke which is "raked out," or "dropped," from the cupola after a melt: many firms pay no attention to this, looking upon it as pure waste. The unconsumed coke should be broken from the slag and taken back to the stage ready for use; if this is done the amount of coke reclaimed will be a surprise to many who pay no attention to this detail. Many cupolas are in constant everyday work without using a slag-hole; if the melt does not extend over much length of time there is not much necessity for one. Many founders allow the slag to run out at the tapping-hole: this is both a wasteful and a dirty method, and should always be avoided. The slag is much lighter in weight than the molten metal, and always floats on the top. In ordinary jobbing foundries it is generally deemed sufficient to keep a "head" of molten iron in the cupola; this keeps the slag from running out at the tapping hole. When melting a quantity of dirty scrap in a melt of two or three hours' duration, the accumulation of slag is liable to hinder the melting process, and the cupola should be kept constantly slagged, the cleanest place for the slaghole being at the back of cupola over the raking-out door. A neat arrangement the writer saw used recently, had a small spout fixed to the top of the back, or raking-out door. A lot of old scrap, burnt fire-bars, etc., was being melted; by running out the slag occasionally the cupola was kept clean. There is no doubt that one, or even two slag-holes, placed a few inches below the tuyères, are a necessity in cupolas working continuously for several hours. If attention is given to this, the speed of melting is greatly increased, the slag floating on the surface of the metal being easily chilled if the cold blast reaches it. If ironfounders who pay little attention to some of the points enumerated in this article will ponder over their present fuel ratio, and go into the matters mentioned, possibly they will be surprised at the saving which could be effected in many instances. No mention is made of any type of fan or blower; but for general work a positive blower on Root's principle, with a pressure of about 20 ins. of water, will give an excellent result.

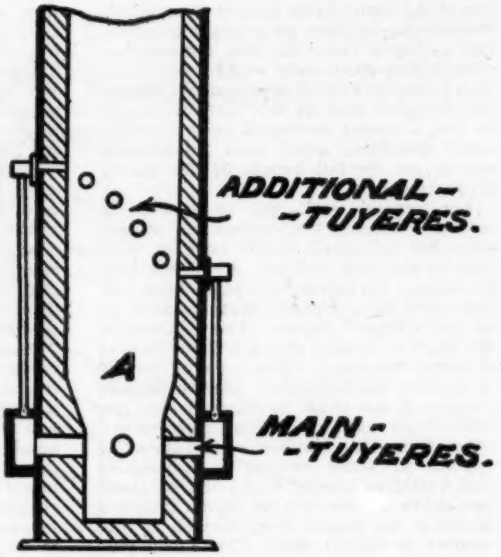


FIG. 5.

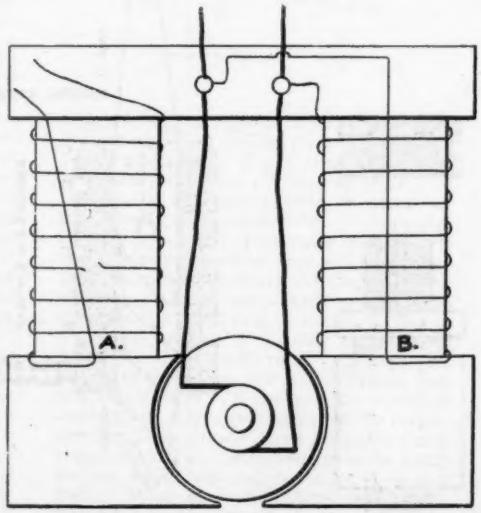
Workshop Practice

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection. See important announcement in advertisement pages.

Temporary Repair to a Dynamo.

ON a shunt-wound dynamo, as per sketch, the winding had broken in one of the field coils, and the machine for the time was useless. To get it going again as soon as possible was of the utmost importance. The unwinding of the wire in the defective coil, so as to repair the break, would have been, under the conditions, out of the question. So the difficulty was overcome by disconnecting the defective winding marked *A* and connecting the coil *B* in shunt across the terminals of the machine. Now let us see what happened. The e.m.f. of a dynamo depends on the number of lines of force cut by the armature in a given time, and the lines of force depend on the number of ampère turns on the magnets. By doing away with one-half of the winding we should lower the e.m.f. of the machine by reducing the number of ampère turns. Now, to cut the same number of lines of force in a given time as before, we must increase the speed of our machine. This was done, and the dynamo gave the required voltage, but at an increase of revolutions. Of course, this would not apply in every case. The machine in question was not overloaded. Where a machine is running its maximum revolutions to do the work it is called upon to do, it would not be wise, from a mechanical point of view, to increase the revolutions. In this case a temporary repair had to be effected; and were such a procedure necessary with a fully-loaded machine, it would be as well to look round and see where the load could be reduced, so as to have on the machine only that which was absolutely necessary.

A. E. W.



TEMPORARY REPAIR TO DYNAMO.

The Rat again.

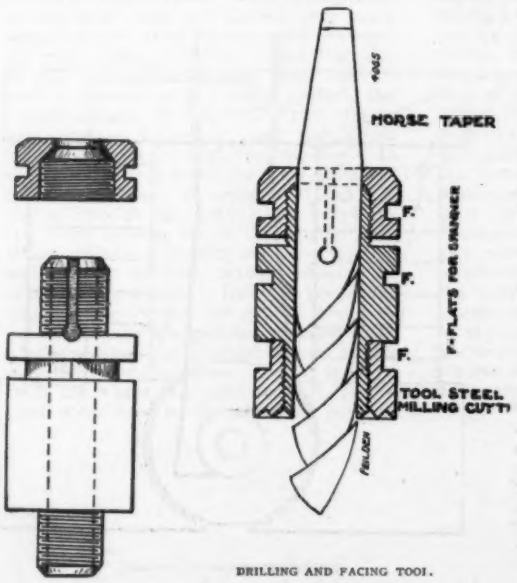
Whilst reading the article "A Rat Sets Fire to a Bedroom" in the June number, I was reminded of an accident that came under my notice a year or two ago. I

was at that time engaged at a large manufactory where the plant was electrically driven and where the installation throughout was of the best and most up-to-date description. One morning, just as the dynamo was started and the current switched on through the works, the armature of a motor driving one section caught fire. When this was taken out and examined it was found that the insulation had been eaten off the wires by a rat, the miscreant himself having met a most untimely death in the midst of his depredations, he being found dead and partially cremated among the wires of the armature. We can only regret that these enterprising rodents, in their thirst for scientific information and electrical knowledge, so often have to pay the extreme penalty of giving their lives for the cause they have so deeply at heart. D. H. M.

A Drilling and Facing Tool.

The drawings shew an attachment for drilling and facing at one operation, which I have found very handy on a great many jobs, especially on valve-seat work, as it prevents a great waste of time in changing drills and putting in cutter-bars, besides being much more durable and producing better work. I have used this in various sizes, from ½ in. up to 1¼ in., and in all cases found it a great improvement on cutter-bars. It consists of a bush made of mild steel, having screwed ends, as shown, the top part being slotted at right angles across the diameter to increase the grip on the drill, as shown in position. The bush is gripped by forcing down the coned collar, the taper of which coincides with that on the shank end of the bush, a slight pressure being sufficient to keep it in place. When the milling cutter is blunt it takes very little more time to sharpen than an ordinary cutter; and the cutter-holder, with ordinary care, should last a considerable time; the holder should be bored about ·018 larger than drill.

GEO. W. W.



DRILLING AND FACING TOOL.

A "Sparking" Trouble.

The exciter of a 250-kilowatt set, direct-driven, gave a great deal of trouble from sparking at the carbon brushes, and on more than one occasion failed to act. Testing showed all the connections, etc., to be faultless, but eventually the trouble was traced to the slight protrusion of the mica between the commutator segments, thus preventing perfect contact. On filing down the sparking ceased, and by polishing the commutator now and again with fine glass-paper the machine ran beautifully. E. M. W.

Re-Boring Crank-Pin Holes.

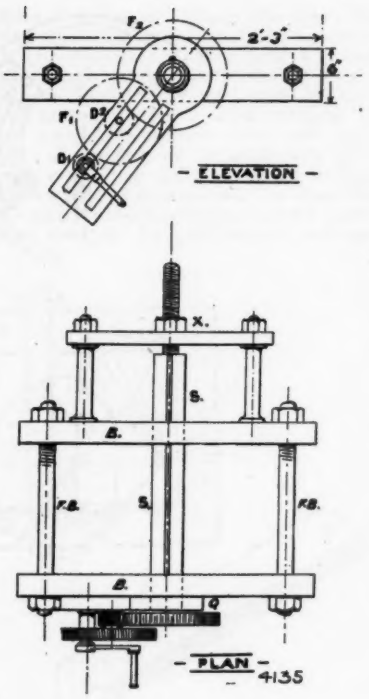
The illustrations show the tackle used to re-bore two crank-pin holes. The engine was a 48-in. cylinder winding engine, and it was desirable to replace the crank-pins without disturbing the cranks, as they were shrunk on and keyed. Also the clutch-gear would have had to come off the shaft before the keys could be driven out. S is a 4½-in. shaft with cutter holes and a keyway in it for the feather key in F_2 to slide along; Q is a quadrant which holds the driving-gear. The arrangement of wheels is as follows: D_1 20 teeth, F_1 50 teeth, D_2 25 teeth, F_2 75 teeth. Thus, 7½ revolutions of D_1 are made while F_2 revolves once. The feed is got by holding the nut X with a spanner, so that as the screwed part of the shaft

S turns round it draws the cutter towards the metal. The whole arrangement is fixed on the job by the bars *B* and the bolts *F B*. The usefulness of the tackle and the ease with which it can be worked are shown by the fact that only three men were required to manage the whole job, while in a similar case where a ratchet-brace was used nine men were wanted.

"WINDER."

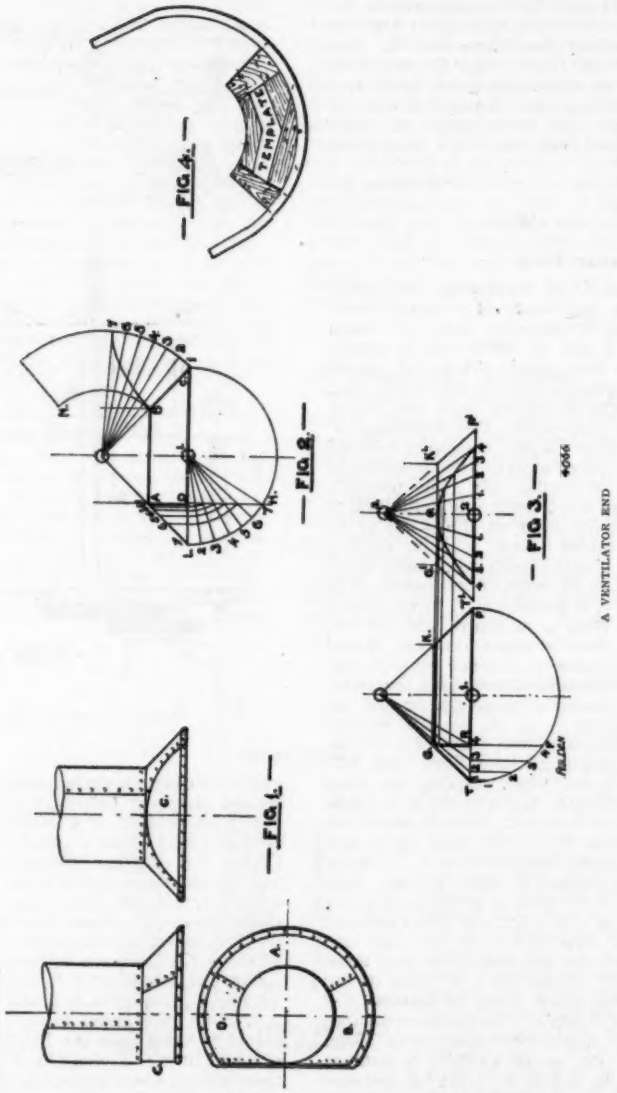
A Ventilator End.

The method of developing the plates to form the bell-mouth of a ship's ventilator, having a flattened side, is shown at Figs. 1, 2 and 3. This type is usually made with four plates, three of which represent segments forming the circular part, and the fourth the flat or back part fitting against the bulk-head. The following explanation will be found of assistance to those who may be called upon to provide templates for this or a similar job. The template method being found preferable to the one of marking out the form on the plates to be used, thin timber—about a ¼ in. thick—used for the purpose being much more easily handled. Lay off shape of bell-mouth, as in Fig. 2, *a*, *b*, *c*, *d*, produce *b*, *c*, to cut centre line in *O*. With *O* as centre, and *Ob* and *Oc* as radii, describe arcs *bn* and *cm*. Round these arcs measure a distance equal to one-third of the circumferences of both diameters of the bell-mouth respectively, *bn* and *cm* join *nm*. Then *b*, *c*, *m*, *n* will be the developed shape of the plate *A*. If the template is made to these lines, care will need to be taken, when marking the plate from the template, that allowance is made for lap where required. Now to mark out shape of plate *B*, use the same figure, and with O^1 as centre describe arc *c*, *h*, *l*. Divide *h*, *l* into any number of parts, say six. Join these points to O^1, join *l*, *O*, produce *a*, *d* to cut radial lines in 1, 2, 3, etc. and with centre O^1 sweep these lines, where cut, up into line *l*, O_1. Then raise perpendiculars from these several points to cut line *l*, *a*. Now on arc *c*, *m*, and from point *c*, lay off distance *C* 7 equal to *h*, *l*, divide *C* 7 into the same number o parts as *h*, *l*, join these points to *O*. Then, starting at *O* 6, set off along *O* 6 distance equal to *l* 6, and at *O* 5 set off distance equal to *l* 5, and so on with the rest. Through these points draw a curve. Then *b*, *n*, *m*, 7 will be the developed shape of plate *B*, care to be taken as before that allowance is made for lap where required. To mark the plate *D*, the template for *B* is reversed. Now to lay out shape of plate *C*,



RE-BORING CRANK-PIN HOLES.

which is simply a hyperbolic section of a cone, lay out shape of bellmouth *G K P R* as in Fig. 3 projection. *P K* cutting centre line in *O*, and with centre O^1, describe arc *P F T*. Divide *T F* into any number of parts, say four, project these up unto line *T* O^1, cutting it in 1, 2, 3, 4, and from these points draw radial lines to *O*. Now take new centre line O_2 O_2 so as not to confuse the diagram. Set off along T_1 P_1, on each side of the centre line, distance O_2 4 equal to *R F*, and O_2 3 equal to 3 3, and O_2 2 equal to 2_1 2, and O_2 1 equal to 1_1 1. Join these points to O_2. Then project across to these lines the heights where line *G R* cuts lines *O T*, *O* 1, *O* 2, *O* 3. Through these points, where projectors cut the corresponding lines, draw a curve 4 *S* 4, this being shape of plate *C*. Allowance must be made for lap, which will require to be flanged a little. Now, after the plates have been marked, punched, sheared, rolled, and put together, the bead iron is put on. This often gives a deal of trouble to those who start to



bend it wrongly. The right method and easiest is first to set it along the edge, using the template from which plate *A* was marked as a gauge, see Fig. 4. Then bend it flat-way by rolling, if possible, and it will then be in the right shape for putting on the bell-mouth. The flat part should be left until the drilling is completed, and after the bead-iron has been fastened on by bolting, the corners should be heated in a fire, when a few sharp blows from a hammer will put it into place, making a first-class job. *(Award.)* BREVI MANN.

Improving Grip on Floor-Plate Patterns.

In order to give a better foothold on the ordinary diamond-pattern floor plate, I would suggest to our readers the putting of a small brass-headed nail—such as are used by upholsterers—in the centre of each diamond on the pattern ; these will be found to give sharp, clean castings, as they leave the sand readily, and are easily removed from the pattern if required. J. H.

A Couple of Repair Jobs.

The illustration, Fig. 1, shows a plan of steam-chest cover which was badly cracked, the fracture running more than half-way across, the escaping steam causing us a lot of trouble. To prevent loss of time, we effected a temporary repair by the following method. Four pieces of 2-in. by 1-in. iron were bent down at one end to form L-shaped clamps, as shown, the long end being drilled to suit the bolts used for steam-chest cover. These were placed across the cover, the bolts and holes in cover and flange being utilised to secure the long end of the clamp bars. A couple of iron "fox wedges" at the angled ends of the clamps, and bearing against the edge of the cover, provided an effectual means of closing the joint ; the bolts round the cover were then tightened up, and the crack caulked with a chisel. The clamps were then removed singly, and the insertion of the bolts as each was removed further assisted to keep the joint good until another cover was cast. Fig. 2 shows how we straightened a 16-ft. length of shafting and trued-up a face-plate coupling on a 10-ft. lathe bed. In doing this we rigged up two pedestals on wooden blocks bolted down to the lathe bed, the pedestals

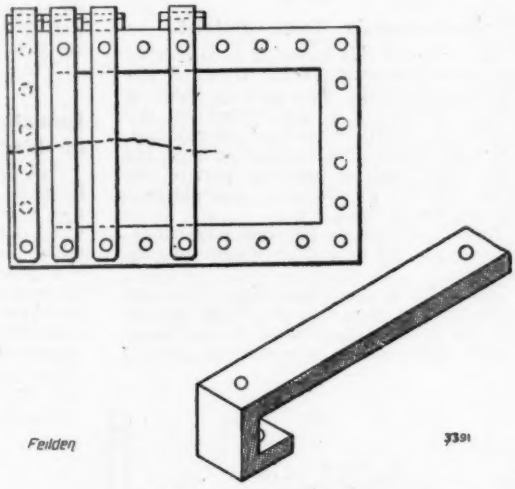


FIG. 1.—CRACKED STEAM CHEST.

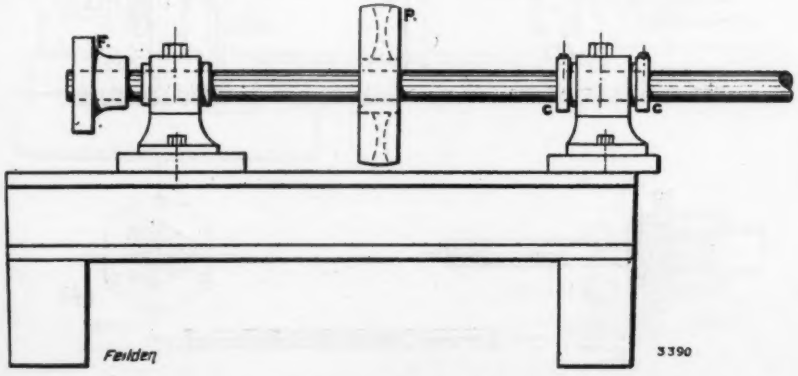


FIG. 2.—CROOKED SHAFT.

being held down by coach screws. After getting the shaft as true as possible by repeated springing—testing after each effort—we put a pulley *P* on the shaft, keeping it fast with a saddle-key. A couple of collars *C*, *C*¹ on each side of the pedestal bearing took up any back-lash. We then ran the shaft by belting from the cone of an adjacent shaping-machine, and taking a cut across the face of the coupling with the slide rest. On the return of the shaft to its position we found very satisfactory results from our primitive rig. REPAIRS.

Hickinbotham's Tap. Patent.

The object of this invention is to provide taps with a secondary valve to cut off the water-supply while the working valve is being repaired, or a new washer put on. With this fitting, when taps are repaired, the water supply does not require to be cut off at the main, or from any part of the house, so that the domestic arrangements can proceed as usual.

By following out the few simple directions, anyone may put on a fresh washer to stop leakage.

Referring to the illustration, *C* is the valve spindle, one end of which can be screwed down on the seating *A*; the flange at the other end of the screwed portion takes the leather washer *F*, which screws on to the seating *M*, to form the working valve.

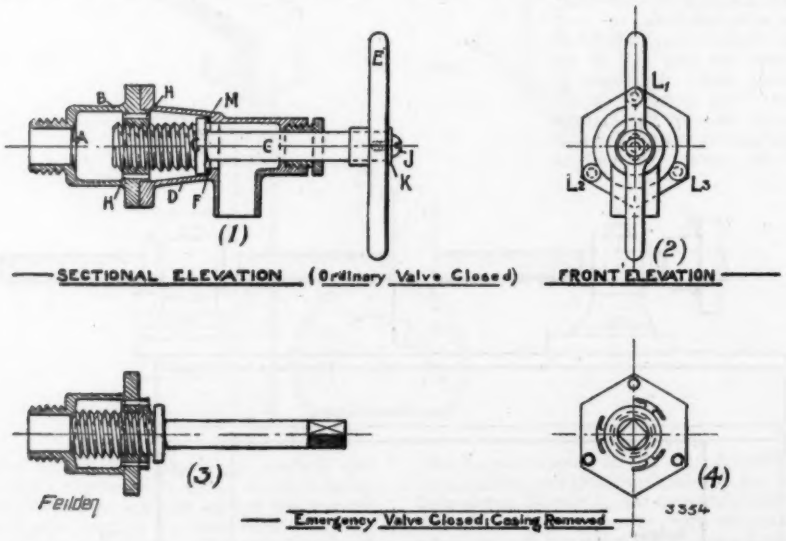
To take off the casing and put on a fresh washer, the tap being shut down by the working valve (Fig. 1), remove the screw *J* and the washer *K*, screw the spindle in as far as it will go, or till the water stops, take off the handle *E*, and withdraw the screws L_1, L_2, L_3, then remove the casing *D*, when the washer will be fully exposed, and can be replaced if necessary. Replace the parts in the reverse order.

In the ordinary way the valve is kept from being screwed too far on opening the tap by the handle meeting the stuffing-box.

B is the connection to the pipe, H_1 H_1 are water-ways.

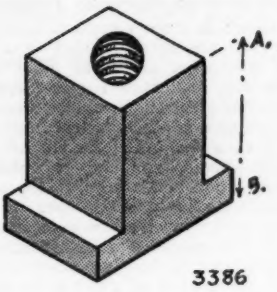
Detachable Bolt-Heads for use on Machine Tables.

One of the greatest drawbacks to the increased output of the modern machine-tool is undoubtedly the want of bolts with which to fasten the work down to the machine table. In most cases these small accessories—a good stock of which are absolutely necessary—are entirely overlooked, and the machinist is left to get them as best he can; especially is this the case in many large shops, where a number of hours are lost



HICKINBOTHAM'S TAP.

weekly looking for bolts and nuts to suit the jobs ; and, moreover, if a machinist possesses a good stock, with being in continual use they soon wear out—threads stripping is the most frequent cause of their failure—and new bolts cannot always be got, as they require forging, and consequently become rather expensive to produce. By far the best and cheapest way to meet this difficulty is to have a number of detachable bolt-heads, as shown in the sketch, whereby straight pieces of black iron screwed at both ends can be used as bolts, and are much more cheaply made than forged bolts and are quite as good, if not superior, to forged bolts for many purposes. The nuts are made out of a square bar of iron shaped down at both sides so as to go into the slots in the machine table ; holes are drilled and tapped through them to receive the screwing, and they are then sawn off to the length required ; they should be as deep as convenient from *A* to *B*, as this is the weak place caused by drilling the tapping hole through. After a trial no machinist will be without them, and will always use them in preference to solid bolts. J. GREEN.



DETACHABLE BOLT HEADS.

Facing Elbow Pipe.

The following is a description of facing cast-iron pipes in the lathe when the bend makes an angle of 90 degs. with the axis of the pipe. In order to augment the output of slotting machine, the following devices were arranged. An angle-plate (*L*, Fig. 1) was bolted on to the face-plate by means of two bolts passing through slotted holes of angle-plate and face-plate, which coincide as shown. The flange is fixed on *L* plate, and two bolts pass through the bolt-holes of pipe and top of plate. The other end of the pipe is supported in a stay as shown,—the stay being stationary, and provided with hard wood bearings and packings, which are raised or lowered by means of set-screws (*B*, Fig. 2). Very good results were got in this way. J. B.

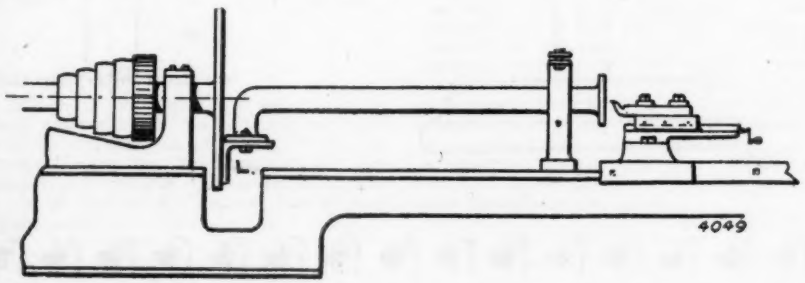


FIG. 1.

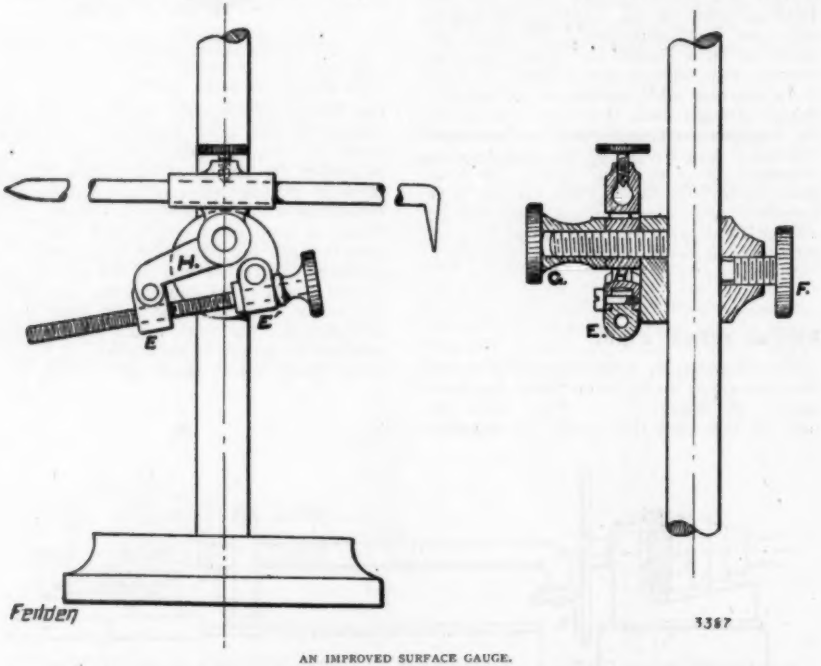
FIG. 2.

FACING ELBOW PIPE.

An improved Surface Gauge

Is shown in front elevation, with section of locking arrangement, and of a design which may prove useful to many of your mechanical readers. I have found the screw adjustment much superior to the "tapping" method of adjusting the scriber when setting to a fine measurement or gauging heights of planer tools, etc. It is also simple in construction, being very little more trouble to make than the ordinary type. It is made entirely of steel, with the exception of the two small trunnions *E*, *E*¹, which are of gun-metal, as also the binding screw *F*; this to prevent the latter from marking the spindle. The adjusting screw is turned in two pieces, the knurled head being riveted on after the neck is passed through the trunnion *E*¹. The nut *G* locking the lever *H* when the scriber is fixed is left solid on the end, which gives it a more finished appearance. The pillar, which is 12 ins. long, has an extension piece 6 ins. long, which may be screwed in the end if required, a milled knob taking its place when not in use.

W. E. IRELAND.



AN IMPROVED SURFACE GAUGE.

AS a further inducement to our Artizan readers, and an additional subject of interest, we have decided to assign one page per month to questions bearing on the Workshop and Practice therein.

A query, if deemed suitable, will be inserted and paid for, together with what is considered by the Editor to be the best reply to the same. The decision of the Editor to be final.

The questions and replies should be written on one side of the paper only and should arrive not later than the *second* week in the month for insertion in the following month's issue.

WORKSHOP QUERIES AND ANSWERS.

WILL some of our readers kindly answer the following?

Cutting Chasers.

What is considered the best method of cutting the chasers for adjustable screwing dies?

Tracing Tools.

Is there anything better and simpler than the check system for tracing tools given out from the tool store? H. H.

Tube Drawing.

I have an aluminium tube 12 ins. long, $\frac{1}{2}$ in. diameter, ·05 in. thick. How can I reduce it to a gradual taper of, say, $\frac{1}{4}$ in. at the other end, keeping it a uniform thickness throughout? J. B.

Circumference of Boiler Shell.

How must I ascertain the length of plate for a given diameter? Also is it necessary to bevel the plate at the ends to form a good butt joint? If extra allowance is made for this purpose, does it vary with the thickness of plate? B. M.

Building Commutator.

Which is considered the better way to build a commutator: on its sleeve cold, and heat it afterwards; or to heat the sleeve first, before placing the commutator on it? As there is a diversity of opinion on this point, I should like to have some of our readers' opinions on it. E. C.

Iron *versus* Steel.

I am at present employed by a firm of heavy-engine builders (slow speed) of high repute, but much to my surprise they use iron, to the almost entire exclusion of steel, for the following details:—Large connecting-rods and straps for ditto, cranks, crank-shafts, and even studs for cylinder covers; which seems somewhat contrary to high-class practice, as far as my experience goes. Can any reader answer, if iron possesses sufficient advantages to warrant its use in preference to mild steel for the above important steam-engine details? W. D.

REPLY TO S. F.

Water in Cylinders.

The position of engine in relation to boilers, also the low pressure of steam employed, will result in a great quantity of water being carried over to engine. To remedy matters, I should fix a catch-box or separator in main steam-pipes. The catch-box can be made of a short length of 12-in. or 14-in. diameter cast-iron pipe, about 3 ft. long, the necessary branches for steam inlet and outlet being cast on same. The top cover should be fitted with baffle or dash-plate, and the bottom cover drilled and tapped $\frac{3}{4}$ in. gas, and fitted with drain-cock and pipe. The drains from engine cylinder and steam chest should be connected up to a receiver—a 2-ft. length of 4-in. diameter flanged cast-iron pipe will answer. Each drain should be carried independently, and non-return valves fitted to each, the bottom cover of receiver to be drilled and tapped for $\frac{3}{4}$-in. wrought-iron pipe, coupled direct to a trustworthy blow-through steam trap—say Royles' "Syphonia," Class D, or to exhaust into atmosphere if required.

R. A. DUNT.

REVIEWS.

Moulder's Text-Book.—By Thomas D. West, 8th Edition, 461 pages, 1901. London: Chapman & Hall, Ltd.; New York: John Wiley & Sons.

This book published a little more than six years ago, is now in the eighth edition, which indicates an amount of patronage rarely given to text-books of this kind.

The author in his preface to the first edition, thanks his patrons and ascribes the success of a previous work to the amount of encouragement received from the English public and the American moulders. We should have been better pleased had he included the English artisan, who is either ignorant of its existence, or is, we fear, too disinclined to make acquaintance with the literature of his trade. The book is divided into several sections, dealing with the defects in castings and the methods for overcoming them, examples in loam-moulding, preparation and running of moulds, cores and core-making, rules for weighting moulds, the management of cupolas, a chapter devoted to the details of American cupolas, another to foundry cranes and the usual tables of circumferences, area of circles, etc. In the chapters dealing with defective castings, the author points out the more frequent causes and the remedies, but one cause he has apparently overlooked, or purposely avoided, *i.e.*, the desire on the part of the moulder to turn out quantity and not quality, so that faulty work may be attributed, not to the want of knowledge on the part of the workman, but the prevalence of "hustling," particularly in the jobbing foundries doing outside work. It is in this class of shop where the making of proper running "gates" and the use of "risers" are practically ignored, the metal being dumped in the mould without any regard to the cleanliness or solidity of the casting.

From personal experience we endorse the methods advocated in the book, and hope to see more attention given to the quality of our castings. Several examples are given in the sections treating on green-sand moulding, the methods of running different moulds, disposition of pouring "gates" and "risers," use and arrangement of "gaggers," "studs" and "chaplets" and the mischief to be apprehended from improper methods in using the latter. Loam-moulding is illustrated to some extent, and the necessary equipment fully described for the production of cylinders, drums and a propeller wheel—we scarcely like the term—but in the latter the information is somewhat misleading and the data insufficient. Some very useful hints are supplied in the making, venting and rodding of dry sand cores, and the methods for best securing them in the moulds. As the author points out, these accessories to a mould are frequently the cause of unsound castings, and too much care cannot be given to their preparation and fixing. The advantages of the use of flour, resin and molasses in combination with sand under various conditions is discussed at some length, with their different effects in light and heavy work.

The making of the core-irons and the venting of cores of intricate form, are illustrated with several diagrams, but we notice an omission of the mention of the ordinary wax taper, which at times is so helpful to the core-maker in venting curved cores. These are rammed up with the core, and the process of drying melts away the outer coating of paraffin, leaving nothing but the charred wick to be blown out of the vent. Much useful information is given as to the economical management of cupolas and the methods and treatment to prevent "scaffolding" and the reduction of slag. In noting the results obtained from American cupolas they appear to be somewhat in advance of our own, as a very short time elapses—three minutes in some cases—from putting on the blast to the appearance of fluid metal, and this, with the remark that the blower in use was too small, however the nature of both fuel and metal may account for this. A few pages and some diagrams deal with the welding together of cast-iron and steel and the burning of defective castings, but this latter process cannot be recommended and must at all times be looked upon with suspicion, as unreliable and unsafe, and having a tendency to destroy the casting by cracking or—when apparently successful—producing extraneous tension; especially in the case of a cylinder should it be condemned and no advantage taken of the possibility of the operation.

Several illustrations of foundry cranes with appended data will be appreciated by those requiring information on the same.

On the recipes for mould facings and the use of blacking of different kinds we can express no opinion, as the constituents differ very materially with those in use here. Several other minor details go to make up a very readable book, and in closing the same after a careful perusal we do so with the conviction that if the methods and instructions contained therein were only *partially* followed out, we should have a greater proportion of better and sounder castings turned out from many of our foundries.

FEILDEN'S MAGAZINE.

Vol. 7. NOVEMBER, 1902. No. 5.

Municipal Socialism.

A SERIES of articles now appearing in the *Times* on this subject bears a strong family resemblance to former articles on "American Engineering Competition" and a "Crisis in British Industry". The present series, like its predecessors, is chiefly remarkable for the presentation of facts and figures in overwhelming profusion, for the avowed purpose of proving that existing methods of municipal government are the result of socialist doctrines and influence, and that these constitute preliminary steps to the "collectivist state." Unfortunately, the *Times* correspondent appears to be an enthusiast who tries to prove too much, and fails to present his facts in the most advantageous form. As a catch-word, "Municipal Socialism" may have been useful during the holiday months, but its employment has not been justified by the articles to which it was applied. Nevertheless, the series in question has been of much interest to all classes of the community, and we fully believe it has done something to show the general public how largely municipal enterprise is overstepping its proper boundaries, and how extensive are the ramifications of municipal extravagance and mismanagement. No one who is moderately observant can avoid the conclusion that corporations and councils of all classes are widely exceeding their legitimate functions, and are adding recklessly to local indebtedness and taxation.

Municipal trading is becoming more and more developed throughout the country, and in some places it constitutes, directly and indirectly, a serious threat to industries upon which the prosperity of the populace largely depends. Municipal enterprise affects private enterprise in various ways; by offering similar services at unremunerative, and therefore lower rates; by increased taxation consequent on trading losses; and by selfish opposition to improved services promoted by independent enterprise.

Few local government bodies adhere to their proper duties of providing merely for the health and safety of citizens. A widely extended view is now taken of municipal responsibility. To take Glasgow as an example, we find the corporation undertake gas, electric light, tramway and telephone services; they control 11 public parks and galleries, 13 baths and wash-houses, 8 markets devoted to the sale of fruit, vegetables, cheese, dead meat, cattle, birds, dogs, and old clothes, 4 slaughter-houses, 4 hospitals and 1 cemetery; and in addition to the buildings mentioned they own over 3,000 others, including houses, shops, workshops, factories, warehouses, public halls, churches and theatres; they also provide a golf course, farm over 1,000 acres of land; they are engaged in market gardening, stone quarrying, in the management of a municipal granary, and in the conduct of various other trades which need not be specifically mentioned.

Probably there is no city in the Kingdom with more extended views of municipal policy than Glasgow, but it may be useful to note some of the more unusual developments in the way of trade that are evidenced in other places. Feeding-bottles and milk for babies are sold by the St. Helens Corporation, saw mills are conducted by the authorities of Cardiff and Battersea, the businesses of wagon building and brush making are carried on by the Manchester Corporation; and not content with the sale of gas stoves, the Birmingham Corporation unblushingly tout for trade as jobbing gas-fitters in unfair competition with struggling tradesmen. Some public bodies would like to go further afield, as shown by proposals to

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